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THE TRAINING OF THE SANITARY ENGINEER

By HAROLD E. BABBITT

Discussion of the training of the sanitary engineer before a group of engineering practitioners should lean toward the practical rather than the academic. Much has been written on training the sanitary engineer to fill certain academic requirements set up, or down, by educators. Less has been written by the practitioner to reveal what is wanted by employers. Too little interest has been displayed by the practitioner in the training and in the employment of the sanitary engineer.

Unfortunately much that is to be said may fall upon sympathetic rather than upon influential ears. The water purification section represents a group of sanitary engineers who are better acquainted with some of the factors in the problem than is the writer. The solution lies, in part, in the hands of superintendents and commissioners.

It might be well to attack the subject at the point where it was left by our General Policy Committee last year. To lead up to that point it may be recalled that slightly more than two years ago a discussion was presented by W. W. DeBerard and myself before the Illinois Section of this Association on the subject of "The Educational

A paper presented at the New Orleans convention, April 26, 1938, by Harold E. Babbitt, Prof. San. Eng., University of Illinois, Urbana, Ill.

Situation in Water Works Engineering." An account of the discussion was published in the Journal, **28**: 921 (1936). The theme of the discussion was that educational institutions are active in preparing young men to pursue careers in sanitary engineering but that industry is neither active in giving employment to these trained men, nor is it grasping the opportunity to secure the best available recruits to its own and to their benefit. A conclusion was reached that, in so far as the water works industry is concerned, something should be done about it.

REPORT OF THE GENERAL POLICY COMMITTEE

In the belief that the American Water Works Association is the most influential body representing the water works industry, the problem of aiding in securing coöperation between the water works industry and educational institutions was presented to the Board of Directors of the Association in January, 1937—in the hope that, as a result of its action, men might be better trained for the job and jobs might be made ready for the men. The matter was referred by the Board to the General Policy Committee which reported in June, 1937 at the Buffalo meeting. The following is an extract representing the pertinent part of the Committee's report:

"With the argument. . .for better recognition by the water works industry of the specially trained college graduate with a concluding recommendation that the Association should interest itself in forwarding the employment of such recruits as a step toward the fulfillment of its constitutional objective. . .this committee is in complete agreement. (however) For the present at least, and until such time as the Association has the membership and income necessary to support activities more definitely pointing to vocational betterment but little more can be achieved than has resulted from the publication of. . .(this paper)."

Such a report leads no nearer to the solution of the problem. It invokes a familiar policy of procrastination by admitting that action is desirable but asserting that now is not the time. Briefly it states that now is the time for inaction. To damn with faint praise antedates Shakespeare. The report does that. It is sympathetic, kindly, and. . .futile. It is unlike the aggressiveness which has characterized our Association and has brought it to its present state of strength and usefulness; it is unlike the aggressiveness of the General Policy Committee to which much credit is due for the present vigorous condition of the Association.

AN OBJECTIVE OF THE ASSOCIATION

The constitution of the American Water Works Association states: "The object of this Association shall be the advancement of knowledge of design, construction, operation and management of water works, and its membership shall consist of persons interested in such matters, having such qualifications and classifications as shall be from time to time prescribed in the By-laws."

We search in vain among the committees and activities of the Association to find anything being done to attain its objective through the education of thoroughly trained recruits to the industry. At present the principal activities of the Association to attain the objective are restricted to the conduct of short courses for water works operators, and the publication of the Journal for the edification of water works practitioners. The annual conventions of the national body and of the various sections serve also to educate the same persons affected by the short courses and the Journal. The Association is not, however, doing all within its power to attain its educational objective for it is neglecting to interest itself in the education and employment of trained personnel. The result is detrimental to the personnel and to the industry which the Association serves.

There is a demand for specially trained young men today. Dr. Compton, president of the Massachusetts Institute of Technology, in an address before the Society for the Promotion of Engineering Education stated that: "the industrial demand for first class young men and the insistent inquiries as to how such men can be secured give a major point of contact between engineering educators and industry."[1] He stated further that shortly before making the address he had been told by the president of one of the country's largest chemical industries that it was impossible to secure a supply of able, well-trained, organic chemists. Probably no president of a water works industry has openly made a similar statement. The water works industry secures its recruits principally from untrained candidates; placing a burden upon the industry and witholding encouragement from the student and the educator.

An opportunity is presented for the water works industry, led by this Association, to help itself and to help others by coöperating in the training and in the employment of the sanitary engineer.

Professional engineers are prone to compare themselves with the medical and legal professions in their rights, privileges, obligations,

[1] S. P. E. E. Journal, September, 1937, p. 38.

and practices. The medical, the legal, and the engineering professions have interested themselves in the training of their recruits; the medical profession through a committee of the American Medical Association; the legal profession through its Bar Association; and the engineering profession through the Engineering Council for Professional Development, more familiarly known as the E. C. P. D.

The E. C. P. D. is an organization composed of representatives of professional engineering organizations whose principal objective is the betterment of the education of the professional engineering recruit. The fact that the A. W. W. A. is not represented in the E. C. P. D. should be a strong reason for the A. W. W. A. to shoulder its obligation rather than to adopt the policy that now is not the time to act. Others are acting now; why not the water works industry?

INDUSTRY'S ACCOMPLISHMENTS

No industry can expect to offer a broad educational training to its employees during their period of active employment, but both large and small industries now interest themselves in and coöperate in the training of engineering recruits for their particular industry. Both a broad educational foundation and specialized studies are best obtained in educational institutions equipped for the purpose. An industry may complete the specialized education of its employee through practice and experience but it is through coöperation with established educational institutions that industry can be most effective and beneficial to all concerned in the preparation of the trained recruit.

The electrical industry is outstanding in recognizing its opportunity and its obligation. It is closely followed by the chemical industry, the steel industry, and other manufacturing enterprises. Is it possible that there may be some relation between the great strides made by the electrical industry, the chemical industry, and other "technocracies" and the fact that it is their policy to coöperate with educational institutions in the education of their specially trained recruits? Probably an equally important policy of these organizations is to send a personnel officer to the educational factory where the recruits are developed so that each special industry may obtain the best available additions to its personnel. The opportunity of participating in such desirable activities is open now to the water works industry.

Sanitary engineering is that branch of the profession of engineering

most closely allied to the water works industry, yet water works departments, manufacturers of water works equipment, and water works associations show little interest in influencing that portion of the training of the sanitary engineer which will make the sanitary engineering recruit more serviceable to the industry. Why is it?

Possibly no water works department considers itself sufficiently influential to approach the supposedly dignified and austere colleges of engineering with a suggestion on how the college might run its affairs to the greater benefit of industry, the college, and the human beings involved.

Water works departments are public service organizations and whether publicly or privately owned they may take their cue for management from the managerial policies of other political bureaucracies. The public is probably the most callous of employers. It is quick to complain of the faults of private industry but it is frequently heedless of its own and its employees' best interests. Political affiliations are all too often placed above merit, and a local resident, however incompetent, is too often preferred above a well-trained but imported recruit whose addition to the community would be a valuable asset. It does not take long for a non-resident to become a resident, nor for a non-voter to become a voter, nor for a potential tax payer to pay taxes. The old fashioned politician kissed the babies who would vote in twenty years but today the wise politician embraces the opportunity to import a valuable addition to his community who, in a year at the longest, may also be a voter added to the party.

Facts and conditions must, however, be faced, and but few, if any, water works departments interest themselves in the higher education of their recruits or in securing recruits from the educational factories. June is the season when the intensively trained recruit is available and June is the season when certain industries come to the educational institutions to select the best of the crop. This is the season when the water works industry should participate in the "rush" and see to it that the industry also enjoys its quota of the better men.

Possibly few manufacturers of water works equipment consider themselves sufficiently important to influence the education of the sanitary engineer. There is no need for this inferiority complex. Other industries coöperate effectively with educational institutions; why not the water works industry? Dr. Compton (in the address

cited above) explained how this coöperation can be made effective and successful. He stated that effective relations might be maintained between engineering educators and industry: "On the part of the teachers. . .(1) by the acquaintance secured through journals, plant visits, and contacts in professional societies, (2) by research on problems in the industry, (3) by acting as consultants for the industry, (4) by part-time employment in industry in summers and during leaves of absence, or simultaneously with teaching duties. On the part of industry the relationship can be maintained (1) by acquaintences through professional societies, journals, and visits to universities, (2) by giving personal help to universities, as through lectures, service on advisory committees and maintenance of contact with university research projects, (3) by financial help to universities through fellowships and grants of funds for research. . .(4) by occasional exchange of staff members between industry and the school." In this manner, and through coöperation in the education and training of the recruit, the manufacturer can both benefit from and exert influence upon the training of sanitary engineers for a career in the water works industry. Dr. Compton points out that some dangers might come between education and industry (1) because of the financial differential between men of equal attainments in the two fields, (2) because of competition between the independent practitioner or consulting engineer, who must stand all of his own expenses, and the more sheltered incumbent of a salaried teaching position, the salary for which may be paid in part by the competing independent engineer, (3) because of large consulting activities by senior members of the teaching staff which might be demoralizing to the younger men who might gain the impression that academic duties are of inferior status, and (4) because of complications which might arise through the development of patented articles and processes and the revelation of industrial secrets. Dr. Compton concluded his remarks by stating that "in spite of all these dangers and complications the importance of close relationship between engineering educators and industry is so great that methods must be perfected for stimulating this relationship and minimizing the dangers and difficulties inherent in it."

WHAT THE WATER WORKS DEPARTMENT CAN DO

If industry can coöperate with educators in the training of engineers, then a water works department should be able to coöperate

with educators in the training of sanitary engineers. Following Dr. Compton's suggestions, the water works superintendent or other administrative official can visit the engineering college, can lecture to the students, and can make available the facilities of his plant for their education. It would be to the advantage of the industry to employ these students during the long vacation and to find a place for the engineering teacher to contribute his ideas, to study the operation of a water works department, and to become better acquainted with the water works personnel.

The water works official who makes provision for such exchanges and coöperation with education is to be commended and will be rewarded for his far-sightedness. The motive for his efforts cannot be entirely eleemosynary, however, for there will be a direct and an indirect return to his department as a result. These returns will include the labor and ideas contributed by the part-time employees and the increased availability of competent personnel for future employment by the industry. Although the water works industry is usually a monopoly, it needs trained recruits to maintain itself and to improve the business through increased economy, avoidance of obsolescence, better salesmanship, and added customer good will.

There may possibly be some water works associations which consider themselves too weak or ineffectual to influence engineering educators in the training of sanitary engineers, but surely the A. W. W. A. should not be included in this category, despite the futile gesture of the General Policy Committee in its report last June. Probably the two organizations which could most effectively influence the training of sanitary engineers are the American Public Health Association and the A. W. W. A.

The influence of the latter could be felt through the adoption of resolutions broadcast to the sections as was the report of the Committee on the Licensing of Water Works Operators; it could be felt through recommendations of policy, and ways and means for accomplishing this policy; and it could be felt through its activities in acting as an agency or clearing house for bringing industry and education together. The influence of the A. P. H. A. on the standard of sanitary engineering education, or more specifically, public health engineering education, is felt strongly as a result of its periodic surveys of the status of education in this field and its tacit recognition of acceptable courses. There seems no good reason that the A. W. W. A. might not occupy the same relative position to education in

sanitary engineering that is occupied by the A. P. H. A. in public health engineering, or the E. C. P. D. in all engineering.

PROSELYTIZING OF SANITARY ENGINEERS

He who recommends to a young man that the profession of sanitary engineering offers a desirable career stands upon dangerous and questionable ground unless he knows whereof he speaks. The profession is anomalous in that many of its practitioners assert that it is interesting, it is not over-crowded, and that it offers an attractive career. Few, if any, however, hold it out as an attractive path to the accumulation of riches. The profession of sanitary engineering offers a competence, an interest in life, and the opportunity for service.

Unfortunately for the young man, these high promises are not always borne out. Four years after the seed has been planted, four years of hard work during which the reward of a place in the field of his adopted profession has been his main hope and inspiration, four years during which he or his parents, or both, have sacrificed economically, the young man says to his professors, to the profession, and to industry: here I am.

And where are the boastful leaders of sanitary engineering? At the moment they may be telling a new crop of young men what fine opportunities there are in the field while the latest available recruits are filling gas tanks. Unquestionably something should be done about it. The situation is not exaggerated, for as this is written there lies upon my desk a letter from a sanitary engineering graduate asking me to aid him in finding a position as he is now among the unemployed—and I have just reviewed a manuscript from an important organization extolling the opportunities in the profession. The aggravation is that the manuscript is correct. There are lots of jobs in sanitary engineering and for sanitary engineers but the industry and the profession should do something about seeing to it that these jobs are available to sanitary engineers and not to untrained interlopers. Something should be done about it.

Dr. F. B. Steinman, the founder and first president of the National Society of Professional Engineers decried the situation when he said: "It is a crime to present to prospective students a too glowing and attractive picture of the material rewards to be expected from an engineering training. The responsibility for subsequent distress and disappointments is on the heads of those who make the presentation,

and on those who lend their names to its sponsorship. It is a crime against the young men, against the profession, and against society. All maladjustment is destructive to the well-being of society. There may be those who deem it desirable to have an abundant supply of low-priced engineering employees always available. But I, for one, do not regard it as a service to society to cheapen the profession. It is not for the best interests of the public to have a profession underpaid and economically degraded,"[2] and may I add disillusioned and unemployed.

The A. W. W. A. represents the public, the profession, and the industry. It can influence education and it can influence employers. There is an opportunity for it to make itself useful. The Association should grasp the opportunity.

SHORT-SIGHTED SHORT SCHOOLS

To avoid guilt by neglecting the objective of "education," as mentioned in the consitutions of various water works organizations, the expedient policy of conducting "short schools" has been adopted. The policy is popular with water works organizations because it panders to the immediate needs of the member and the prospective member of the association. It is popular with the attendants at the short school because it gives much for little. It is popular with the health official because it alleviates the situation resulting from the employment of untrained recruits by the water works industry; and it is popular with the educational institutions because it offers opportunity for friendly contacts with industry for which the institution is hungering. The water works short school is a palliative; it is not a cure; and it may fasten itself upon the industry as the delightful and soothing drug habit upon the addict.

The water works industry may be stultifying its influence in the training of its recruits through the dissemination of inadequate and incomplete information during these short courses. The "graduates" of the short courses feel themselves specially trained in the field of knowledge covered by the course. Employers feel that attendants at such courses have received basic knowledge. The attendants are usually older and more experienced than the more thoroughly trained recent college graduate. The "job" or the promotion is given to the short course graduate and discouragement is given to the "long course" man who has received more thorough training for the prac-

[2] American Engineer, December, 1937, p. 7.

tice of water works engineering. It is from this point of view that the water works industry may be stultifying itself by placing, as it does, its entire educational efforts on the conduct of short schools.

This apparent castigation of the promoters and conductors of water works short schools must not be understood as a condemnation of the enterprise. The point to be emphasized is that the short schools are right in their place but that they should not occupy the entire place in the educational activities of water works associations.

WHERE LIES THE BLAME

It is possible that the lack of interest in the training of sanitary engineers for the water works industry is not altogether the fault of the industry. Some of the difficulty may be laid at the door of the educator. Rare indeed is the college graduate who cannot propose a revision of the course from which he was graduated. Some subjects should be added to fill the need which his subsequent experience has made him feel. All want something added but rare indeed is the critic who wants to take something from the prescribed course of study. Like the cost of government the number of studies pursued by a college student is always rising.

The student in the professional engineering school today is a busy individual. He is human and he resents the addition to his burden and hails, with as much delight as the school boy, a holiday, a vacation, a snow storm, or anything which may interrupt the deadly grind onto and into which he has embarked.

Appreciating this state of mind on the part of the student, the educator is prone to sympathize with it and to turn a deaf ear to proposals to extend the course. Possibly it is at this point that the educator may be somewhat at fault because of the lack of coöperation between the water works industry and the training of the sanitary engineer. It is a possibility. The possibility may be turned into a certainty or refuted through a successful attempt by either the educator or the industrialist to coöperate, one with the other, in the training of the sanitary engineer. There is an opportunity for both.

CHANGES IN WATER UTILITY ACCOUNTING

By E. W. Morehouse

The Uniform Classification of Accounts Committee of the A. W. W. A. has asked me to explain briefly the changes made in the revised uniform system of accounts recommended by the National Association of Railroad and Utility Commissioners. I shall do the best I can to anticipate what features of the new system you, as operating men, are most interested in. From the operating standpoint I assume you are most interested in accounting for property and plant and operating expenses. Accordingly, these subjects will occupy most of this paper.

But first let me give you a little history to show the present status of the revised system of accounts. In 1921 the N.A.R.U.C. first recommended a uniform system of accounts for water utilities. More than a decade later the N.A.R.U.C. Committee on Statistics and Accounts of Utility Companies undertook a revision of this system. This revision was patterned after the previously adopted revisions of the classifications of accounts for telephone, electric and gas utilities. In September, 1937, at the Salt Lake City convention of the N.A.R.U.C. the Committee recommended a revised draft, subject to perfecting amendments after further conferences with state commissions and representatives of the industry. This recommendation was approved by the N.A.R.U.C. Last October we met with representatives of the industry and discussed the changes and suggestions they brought forward. Certain of the industry's suggested changes were adopted and these will be submitted to the next convention of the N.A.R.U.C. If approved, they will be made in the draft recommended last September before submitting to the printer. A few states, such as New York, Wisconsin and West Virginia, have ordered revised systems of accounts into effect or have such revisions under consideration. These states have followed, in the main, the system approved by the N.A.R.U.C.

So much for history.

A paper contributed by E. W. Morehouse, Wisconsin Public Service Com., and Chairman of the Committee on Statistics and Accounts of the National Association of Railway and Utilities Commissioners.

Brief mention should be made of the groups of accounts on the balance sheet and in the income statement. The balance sheet for water utilities follows that previously revised for electric and gas utilities. More accounts are provided than in previous water systems, the intention being to make the balance sheet more informative to investors, regulatory bodies, and the public. This is in keeping with the trend in accounting generally.

BALANCE SHEET AND INCOME STATEMENT

Two new features of the balance sheet should be noted.

1. Provision is made for classifying property and plant into seven groups, instead of lumping such property into two accounts as in the old system. With all property in practically one account in the old system, it was not possible, without special study, to know how much of the property was devoted to utility service or on what basis the book cost of the property was stated. In the new system, physical property not used in utility service is put in a separate account. Construction work in progress has an account by itself, as formerly. Utility plant is then classified as to whether it is being used in service, is leased to others or is held for future use. It is provided that utility plant in service shall be recorded at original cost at the time when first placed in utility service, and any differences between original cost and book costs at which previously carried shall be segregated in separate accounts. Of this feature more will be said later.

2. A balance sheet account is provided for showing separately commissions and expenses on capital stock. Formerly this item was usually buried in "fixed capital" as an item of organization expenses or miscellaneous intangible capital.

Not much important change is made in the income statement except in calling depreciation expense by its proper name. This will be referred to again. There are a few more accounts, chiefly in connection with the additional property classifications. Provision for uncollectible accounts is removed from the income statement as a revenue deduction and in the new system is included with the operating expense accounts. The arrangement and captions in the revised income statement are patterned after the new system of accounts for electric utilities.

REVENUES

In the revenue accounts the changes are minor. A separate account is provided for private fire protection service as distinguished from public fire protection service. Separate, new accounts are provided for interdepartmental sales and for interdepartmental rents. The chief change affecting operating routines is that in the new system credits to the revenue accounts shall be made on the basis of the net price charged. Forfeited prompt payment discounts or penalties for late payment are combined and placed in a separate revenue account. In the old system, revenue accounts were credited on the basis of the gross price charged to water users, and forfeited discounts or penalties were charged to the revenue account to which they related. This change will require an alteration in accounting routines which, once accomplished, should save some time and expense.

UTILITY PLANT ACCOUNTS

In discussing the plant and expense accounts, it should be borne in mind that the revised system was drafted for only the larger utilities, Class A with operating revenues of $250,000 or more, and Class B with revenues of $100,000 to $250,000. While the same primary plant accounts might well be used for smaller utilities, the operating expense accounts can be consolidated somewhat without loss of effective accounting control.

The principal change in the revised system of accounts is in the accounting for property and depreciation. The number of plant accounts, their captions, and the classification of items includible therein have been altered only slightly and are therefore omitted from further discussion herein. The exclusion of capital stock expense from intangible property has already been mentioned; it is of relatively small significance because such a large proportion of water utility property is now owned by municipalities. The three really far-reaching changes in accounting principle are: (1) Classifying and stating the utility plant at original cost; (2) distributing the overhead costs and expenditures among the plant accounts to which they relate; and (3) depreciation accounting.

1. *The original cost principle.* This topic can be discussed most appropriately under three headings: (a) What has been done? (b) Why was it done? (c) How is it to be accomplished?

(a) The revised system of accounts provides that the utility plant in service shall be recorded in the accounts on the basis of original cost which is defined as "the cost of such property to the person first devoting it to public service." Since plant constructed by the present owners presumably has been recorded, under proper accounting, at original cost, this principle applies only to property purchased as a going concern and constituting an operating system. It does not apply to the purchase of a block or two of distribution main, forming part of a larger system.

Let me give a hypothetical and simplified illustration. Assume a water utility plant, costing $100,000 when originally installed on which has been accumulated a depreciation reserve of $30,000. The property is purchased, let us say, for $90,000. The revised system of accounts provides that the new owner shall record the property in his plant in service accounts at $100,000 and in his depreciation reserve account at $30,000. The difference between the purchase price ($90,000) and the depreciated original cost ($70,000) or the amount of $20,000, shall be recorded in a separate plant account designated "Utility Plant Acquisition Adjustments."

It is also provided that if the present owners have restated the book cost of property at a higher or lower figure than the cost to them, when acquired or installed by them, that difference shall be segregated in another separate account, "Other Utility Plant Adjustments." This account, then, is to carry "write-ups" or "write-downs" from revaluation of property while in the hands of the present owners.

(b) Why was this done? Under the old system of accounts, special studies were needed to determine on what basis utility plant was recorded in the accounts where the present owners had purchased substantial amounts of property as going systems. Ordinary investors were in no position to make such studies. Citizens of a municipality which had purchased its water system were similarly handicapped. Regulatory bodies were delayed in taking appropriate action. In many cases purchased property remained unclassified and there was frequent doubt whether upon retirement the property was removed from the accounts at a proper figure. While it is true that these defects pertain chiefly to electric and gas utilities, a significant part of water service is rendered by private companies, frequently along with other utility services, and many municipalities are operating properties bought from former private owners.

From the standpoint of regulatory bodies, having original cost of the plant readily available aids speedy and effective regulation, particularly in rate-making, but also in passing upon security issues, reviewing depreciation rates and valuations underlying tax-assessments. Original cost, being relatively stable, promotes uniformity in plant records and statistical data and affords a useful basis for accounting for plant retirements. These purposes are also important from the standpoint of management. Moreover, from the point of view of the citizens of a municipality served by a public water plant, comparison of costs of service in different communities may be more assuredly made if a standard basis of stating plant costs is used.

Many utilities criticized these new requirements severely. Some of the arguments were red herrings brought forward in the heat of controversy; others were exaggerated or based on misunderstandings of the new system; and still others were of a legal nature and were litigated in the so-called A. T. & T. accounting case. In that case the United States Supreme Court finally upheld the new regulations* which quieted the agitation for obstruction. I have reviewed these arguments elsewhere** and it would serve no useful purpose to repeat them now. The original cost principle is now in effect for most telephone and electric properties and is being tested by experience. I venture the guess, not verified by any calculations, that on the whole the water supply industry has relatively less property subject to reclassification on the basis of original cost than in the electric industry and that consequently compliance with the new requirements will generally be less difficult than many persons have anticipated.

(c) How accomplished? The new system of accounts provides that the property recorded as of the effective date of the new system shall be placed temporarily in a separate account labeled as "Property Subject to Reclassification." When these amounts have been analyzed to determine original cost and when overheads are spread, they are to be transferred to the new accounts as appropriate. For most water utilities with adequate property accounting in the past, this should not take very long because probably in the majority of cases present owners have installed the property themselves. It is important that present property be reclassified as soon as possible and not permitted to remain unanalyzed and also that new units

*American Tel. & Tel. Co. v. U. S., 299 U. S. 232 (1936).
**Yale Law Journal, April 1937.

installed shall be classified in the new accounts. Two years is suggested in the revised system.

Where acquired property does exist, some studies and estimates may be needed. If the property records of predecessor owners are available and adequate, the determination of original cost may be a matter of accounting studies only or chiefly. In other cases, appraisal studies may be necessary. That estimates may have to be made is not fatal to the principle. As you operating men know, your present accounts reflect many figures which are only estimates. Substantial adherence to original cost, rather than accuracy to the last cent, is all that is required.

The alleged cost of installing the new system has frequently been stressed. Some operators have been frightened by this. I ask you to bear in mind, however, that even where such cost estimates have not been exaggerated, these costs of initial installation are not recurring. Once the property has been reclassified and adequate records and accounting routines set up, the annual cost should not be much, if any, greater than formerly. Against such added annual costs, if any, should be set the benefits of useful information more readily available.

I cannot leave this subject without two reminders. The original cost basis of property accounting might never have been required if certain utilities had followed more conservative accounting practices in the past. These new requirements do not destroy the record of cost to the accounting company any more than such cost is impaired by the first retirement of a unit of acquired property. What is required is a different classification of what is now recorded on the books.

2. *Overhead Costs.* Under the old system of accounts, separate accounts were provided for such overhead expenditures or costs as engineering and superintendence, taxes and interest during construction, etc. In the new system these costs are required to be assigned to the several classes of property and each job or unit to which they relate.

Experience with the old system disclosed that all too often, when property was retired, the overhead costs applicable thereto were overlooked. The new system is designed to guard against this oversight. It will necessitate the distribution of now undistributed overheads, but this will require no more difficult estimating than in some other phases of accounting. The new requirement is in the

interest of more accurate property accounting, especially in pricing retirements.

3. *Depreciation Accounting.* The old system of accounts provided for retirement reserve accounting; the new system requires depreciation accounting. The old system did not prohibit depreciation accounting, but neither did it prohibit making provisions for retirement contingent upon earnings available for dividends. In the revised system, depreciation is treated as a cost to be reflected in the income statement for each accounting period. This cost is specifically defined and the service value of depreciable property is required to be spread over the estimated service life of the property. However, no specific method of accruing depreciation is prescribed. This is left for determination by the regulatory bodies or accounting utilities in each jurisdiction. The aim in these provisions is to avoid the rather loose accounting for depreciation that has prevailed in the past.

Some utilities have interpreted the original cost accounting regulations as requiring them to write off immediately any differences between the purchase price of acquired property and its original cost. This is not so. Provision is made for separate accounts to amortize amounts recorded in the acquisition adjustment account. This account may be used substantially like a depreciation account depending on the nature of the item of adjustment and the requirement of regulatory bodies.

OPERATING EXPENSES

The changes made in operating expense accounts are not numerous and in general follow the principles used in the electric system of accounts, with adaptations to the peculiarities of the water supply industry. A few of these changes are briefly summarized.

Instead of separate groups of operation and maintenance accounts for each kind of power used in pumping, power and pumping expenses are grouped with a provision that they be subdivided to show the cost of operation and maintenance of each kind of power used. Commercial and new business expenses are classified into two groups, captioned "Customers' Accounting and Collecting Expenses" and "Sales Promotion Expenses." In this respect, the revised system for water utilities follows those for electric and gas utilities. Except in these two groups of accounts, separate debit and credit accounts are provided for joint expenses in each functional group of accounts.

Rent expense accounts are provided in each functional group. Operating rents are to be apportioned, where practicable; if not, they may be included in an income account as in the old system. Joint facility rents and expenses are provided for in the revenue and expense accounts, it being intended that the revenue accounts shall include only amounts received or transferred covering depreciation, taxes and interest, and that amounts received or transferred representing operating or maintenance expenses shall be accounted for through joint expense or clearing accounts.

Possibly the operating officials of a water utility will be most concerned with the treatment of supervision and engineering expense. Instead of combining such expenditures in one account in each functional group, separate accounts are provided for supervision of operations and maintenance supervision. In this respect the revised system follows the revision of the electric and gas systems for the larger utilities. The aim, of course, is to provide a means for functional cost accounting.

Many other provisions might be commented upon, but these I believe will suffice to give you a picture of the revisions made. Except possibly in the matter of accounting for original cost of property, the changes made are not of revolutionary proportions. The Committee on Statistics and Accounts of Public Utility Companies of the National Association of Railroad and Utilities Commissioners has been aided greatly by the review made by, and suggestions received from, the A. W. W. A. Committee on Uniform Classification of Accounts.

All these revised systems of accounts—telephone, electric, gas and water—are entering upon a period of application and interpretation. Accounting is a progressive science. Experience in the future will doubtless point to desirable improvements. I ask you to give the revised system for water utilities a fair trial to the end that accounting for all the operations of a water utility shall be made constantly more accurate, informative, and useful.

REPORT OF THE UNIFORM CLASSIFICATION OF ACCOUNTS COMMITTEE

This committee was appointed to review a draft of a uniform system of accounts for water utilities prepared by the Committee on Statistics and Accounts of the National Association of Railway and Utilities Commissioners. In view of the short time given to this committee for the review of the draft it was impracticable to hold more than two meetings. Consequently, recommendations were confined to items which the committee considered important.

After the committee's report on its recommendations was completed and forwarded to Mr. Morehouse, Chairman of the N.A.R. U.C. committee, your committee was invited to attend a meeting of the N.A.R.U.C. committee at Washington, D. C. on October 25, 1937 for a discussion of the suggestions submitted. The chairman of your committee and William Schwartz, representing C. J. Alfke, attended the meeting and presented this Association's views.

The following members of the N.A.R.U.C. and persons invited to attend were present at the meeting: Dr. E. W. Morehouse, Chairman, Wisconsin Public Service Com., Charles C. Drummond, Virginia Public Service Com., William V. King, Federal Power Com., Ace Colpert, Wisconsin Public Service Com., Malcolm F. Orton, New York Public Service Com., J. Donald Murray, West Virginia Public Service Com., Henry Long, Federal Communications Com., J. C. Masson, Maryland Public Service Com., and Horton L. Chandler, New Hampshire Public Service Com.

A report submitted at the New Orleans convention, April 26, 1938, by the Committee on Uniform Classification of Accounts. Members of the committee are as follows: L. D. Blum, chairman, C.P.A., 110 E. 42nd St., New York City; C. J. Alfke, Mgr., Hackensack Water Co., Weehawken, N. J.; L. M. Anderson, Controller, Dept. Water and Power, Los Angeles; Harry Boggs, C.P.A., 803 Electric Bldg., Indianapolis, Ind.; H. T. Ellwood, Chief Accounting Officer, Federal Water Service Company, 90 Broad St., New York City; M. F. Hoffman, Commercial Supt., Dept. Water Works, Cincinnati, Ohio; L. E. Sharpe, Asst. Controller, American Water Works and Electric Co., 50 Broad St., New York City; and Hal F. Smith, 401 Water Board Bldg., Detroit, Mich.

Topics discussed were as follows:

1. General instructions relating to separate records for the cost of each plant and the cost of operating and maintaining each plant.

2. Utility plant account with special reference to the recording of original cost to the person who first devoted the property to utility service.

3. Additions and retirements of utility plant.

4. Services with special reference to what constitutes inactive services and when they should be retired.

5. Hydrants.

6. Treatment of property paid for by consumers upon retirement.

7. Recording of revenues.

8. Cost of maintenance.

In connection with the recording of the plant account and the maintenance of records for the cost of each plant, your committee was under the impression that the classification required continuing property records. The committee of the N.A.R.U.C. informed us at the Washington conference that such continuing property records were not required by the classification but that each Commission adopting the system could make such records mandatory if it desired to do so. One of the questions raised by your committee was the eventual disposition of plant in excess of original cost. Your committee contended that it should be amortized over the same period used for depreciating the original cost of the property. With reference to this contention, we were informed that the proposed classification did not contemplate the amortization of the excess over cost over an unreasonably short period, but that it was intended, under the classification, to leave the question of the term of amortization in the hands of the Commissions.

The question of retirement units was also discussed at the Washington conference; the committee of the N.A.R.U.C. decided that a uniform list of such units was desirable and that it would undertake the preparation of one. Your Committee was invited to collaborate with the N.A.R.U.C. in the preparation of the list of retirement units. In accordance with the request of Mr. Morehouse, several lists of retirement units in use by privately owned water plants were submitted to him. This list, when completed, should prove very helpful in advancing uniformity in accounting for plant.

The uniform classification of accounts, as recommended by the Committee on Statistics and Accounts of the N.A.R.U.C., in its

final form was released and practically all of your committee's recommendations were incorporated therein.

This committee wishes to take this opportunity to compliment the N.A.R.U.C. on the new classification which, in the opinion of this committee, reflects the unusual experience, ability, and earnest effort of the Committee on Statistics and Accounts of the N.A.R.U.C.

It was indeed a pleasure for us to collaborate with Mr. Morehouse's committee and in behalf of the A.W.W.A. we wish to express appreciation for the opportunity to review the uniform system of accounts and submit our suggestions.

Personnel of the Committee on Uniform Classification of Accounts

C. J. Alfke	H. T. Ellwood
L. M. Anderson	M. F. Hoffman
L. D. Blum	L. E. Sharpe
Harry Boggs	Hal F. Smith

Submitted by L. D. Blum, *Chairman.*

THE CONTINUING PROPERTY RECORD AND ITS USES

By Carter H. Lamb

With the advent of the Continuing Property Record the engineer and the auditor have been united in a common effort; the engineering and accounting departments have joined forces in producing and maintaining a record that definitely ties the physical property unit to its cost. Usually when records of water works property were considered it meant only a record of the dollars set up in the accounts, and to tie units of property to these costs necessitated references to superintendent's personal notebooks or detailed investigations of old files, and even then it was often doubtful whether all the costs had been included or not. The continuing property record when carefully compiled and maintained shows at a glance the net cost to the end of the last calendar year of all items of physical property.

The orders of the Public Service Commission requiring continuing property records that I have seen do not define the term except by listing the requirements. My own definition of a continuing property record is an inventory and cost record of fixed capital property arranged in such fashion that, by deducting retired units and adding new units year after year, it becomes a continuing record of the units and costs of the physical property of the utility.

Of course, accountants will recognize that this is not a new record for they have all had experience with the so-called perpetual inventories of materials and supplies and will note considerable similarity.

Some years after the Interstate Commerce Commission began valuation of the railroads of the country, it found it necessary to set up a method whereby the inventory and cost record could be continued from year to year. This was effected by an order prescribed: "Requirements and instructions to govern recording or reporting of all extensions and improvements or their changes in physical property of every common carrier." This became effective January 1, 1919 and is known to railroad men as Order No. 3. This was, in effect, the establishment of the continung property record for the railroads of the country.

A paper presented at the New Orleans convention, April 26, 1938, by
Carter H. Lamb, Valuation Eng., Jamaica Water Supply Co., Jamaica, N. Y.

On October 20, 1936 the Public Service Commission of the State of New York ordered water works corporations to establish continuing property records effective January 1, 1938. I understand similar orders have been issued to the other utilities of the state. Some of the requirements of this order are as follows:

ORIGINAL COST

It is required that the original cost, actual or estimated shall be the cost set forth in the continuing property record, and original cost in this requirement is defined to mean the cost of the property to the person or corporation first devoting it to public service. Perhaps this requirement, more than the order for the establishment of the record itself, has caused much of the controversy between the utilities and the Commission.

There are two reasons for the opposition of utilities to this requirement of original cost. One is the effect upon the financial structure of the utility, and this phase of the subject I will leave to those more capable of discussing it.

The second reason for opposition to the requirement of original cost is the difficulty and work required to establish such a cost. With the books of account of the original companies destroyed or missing, it is often impossible to determine the actual cost of the property to the first users. However, I want to call your attention to the fact that the Commission's order assists in this matter by permitting the utility to estimate this original cost when it cannot be determined from the records. Of course, an adequate estimate also requires considerable work and good judgment, but it is usually on a small portion of the total property and I believe can be so determined as to meet the approval of the Commission. What I have found to be a major element of successful negotiation with any Public Service Commission is an honest effort to comply with its requirements.

At this point perhaps it would be helpful if I mentioned my own experience in the determination of original cost for the Jamaica Water Supply Company. We had no difficulty due to past mergers or consolidations, but the loss of practically all construction records prior to 1917 necessitated an estimate of the original cost of the property still in service that was installed in the thirty-year period, 1887 to 1917. This property consisted mostly of distribution mains, hydrants, corporation cocks and meters. In connection with the distribution mains and hydrants, we redrew our distribution maps

and on these we plotted the mains and hydrants installed from 1917 to date as shown by a detailed analysis of the actual work orders and construction records. The remainder of the distribution mains and hydrants taken from our old map records and spot-checked in the field gave us the intentory of this property prior to 1917 which had to be estimated. Unit costs for the various sizes of cast-iron pipe in place were estimated from a history of cast-iron pipe prices with allowances for over-weight, waste, and specials together with the labor of installing based upon the wage rates actually paid as obtained from the recollections of some of the old timers with the Company. In a similar way the unit costs for valves and hydrants were estimated. These estimates were reviewed in detail and approved by the Commission's Engineering staff in connection with a rate case then in progress. Considering that less than 15 per cent of the present value of the property was involved in this estimated portion, it did not prove to be such a difficult task as had been contemplated.

UNITS OF PROPERTY

Another requirement of the Commission for the continuing property record is that the property of the utility shall be divided into units arranged to conform with the water plant accounts, and that each unit shall be fully described in the record. Details required in this description are:

1. Date when charged to water plant accounts.
2. Location—street, town and tax district.
3. Manufacturers name and number, if any.
4. The Company's number or designation.
5. References which will show the source of all the entries and all supporting data.

There is some difference of opinion as to what should constitute a unit of property for the continuing property record. The Commission's order helps only to the extent of designating that each parcel of land and each structure may be considered a unit of property, and that large quantities of similar units may be grouped and the average costs for the units installed in a calendar year may be used. In general, I should say that in plant accounts the unit should not be broken down any further than the actual contract costs are divided. In other words, if a building is constructed under a contract, I should set it up as one unit and in the event that a portion

of this building is later retired, I should then consider the necessary break-down of cost for that purpose.

A good deal of interest usually centers around the handling of the elements of distribution mains. I have considered in the continuing property record for my Company that the average cost of one foot of pipe of each size, including fittings, installed in each calendar year is a unit. Likewise, the average cost of each valve, gate box and manhole, and of certain miscellaneous items which were included in this account, is considered a unit. While it is a fact that the actual cost of installing one foot of pipe in any year may vary considerably in different locations in our territory, depending upon soil conditions, interference with other underground utilities, weather conditions, etc., yet the difficulty of determining separate unit costs for each of the 400 jobs or more of pipe extension work that we do every year far off-sets any disadvantage there is in the average unit method. In the hydrant account, similar average unit costs for installations each calendar year are determined. These unit costs are per hydrant, per foot of 4-inch lateral, per foot of 6-inch lateral, per 4-inch valve and per 6-inch valve.

A very important part of the continuing property record is the summarization. Of course, a separate summary of each account is necessary as well as final summaries by accounts and by years. These summaries are usually of dollar values only, as the property units covered in the detail record cannot always be added together.

The continuing property record may be ever so accurately built up and established, but if it is not properly maintained by a working department using a workable system, it will be of little value in a few years time. The system of job accounting in force prior to the establishment of a continuing property record should be thoroughly reviewed and such changes made as are found necessary to give to the new department copies of all basic records required to analyze the cost of new work and to properly set up the retirements. For instance, copies of the authority for the expenditures, the estimate of cost, maps and drawings, requisitions and returns, vouchers, payroll distribution coupons, transportation charges, store charges, and other overhead charges should all pass through the department either for notation and return to accounting department, or as duplicate forms for filing with the job analyses envelopes in this new department.

Perhaps the department can absorb to advantage some of the work

now carried on by other departments. For instance, my department is in charge of the distribution maps, keeping them posted and furnishing new sets each year to all departments. We prepare the estimates and field sketches for all pipe extensions so that we have a knowledge of jobs before they are started, and if for any reason we need information not usually furnished by the Construction Department we send an engineer out on the job to get it.

We use only two final forms on which our continuous property record is carried forward, one $8\frac{1}{2}$ x 11-inch sheet for plant property and one 11 x 17-inch sheet for mass property and summaries. I do not believe that a multiplicity of forms is necessary; no form, however complex, can meet all requirements, while a trained personnel can use a simple form to cover all requirements. After two years of operation (and four years of recorded information) we have no change to suggest in our forms but to provide for more years in the future.

While every effort should be made to establish completely the record after starting on it, yet there are some elements that I consider as a part of the record that need not be completed before the dead line. I refer to supplementary records, such as the distribution maps, real estate survey plots, meter records, hydrant records, valve records, etc. Some of these held over make good fill-in jobs for the department to work on between month-end and year-end rush periods. We have had our continuing property record working for two years now and we have a supplementary record of distribution maps, hydrant cards, and meter cards, but we are still working on a valve card record, and also have plans for a better check on furniture and tools by some sort of a metal tag numbering system.

This brings up the question of how this work should be organized. Some utilities consider that it is a function of the accounting department and should be supervised and maintained by that department. Others believe that the requirements of an engineering analysis of all new property installed and of the retirement of old property necessitates the setting up of a special department supervised by an engineer. The railroads usually organized the work as a separate department, but some put it under the supervision of the accounting officer and some under the chief engineer.

In my experience in charge of this work, both with the railroads and the utilities, I have found that it requires somewhat of a "Jack of all Trades," in that while an engineer's training and experience is very definitely needed, a considerable knowledge of accounting is

also necessary and some knowledge of legal procedure is an advantage. I believe that the continuing property record should be established and carried forward by a separate department organized for the purpose and supervised by an engineer trained in valuation work. Of course, this department must work in close harmony with the accounting department, as its record must be reconciled with the books of account each year. However, most of our troubles come from the construction superintendents, and it requires considerable engineering ability and tact to get detailed reports from the field that are ready for analysis and accurate accounting.

The cost of establishing a continuous property record is so dependent upon the size of the property, the present condition of the construction records, the amount of property that has to be estimated, the condition of distribution maps, the requirements for field inventories or checks and other matters that an estimate is hardly worth while. However, in general a range from 0.1 to 5.0 per cent of the total original cost ought to cover it.

Likewise, the annual operating cost of a valuation department would vary depending on size of property, amount of new construction work, etc., but should average about 30 per cent of the initial cost.

Of course, the most useful purpose of the Continuing Property Record is to support the water plant accounts in the uniform classification of accounts and assist in accurately accounting for the retirements in each year. A reconciliation must be established each year with the books of account, and by close coöperation with the accounting department this can be accomplished without undue effort.

Another useful purpose of the continuing property record is its helpfulness in the maintenance of a depreciation record. If the utility, either by Commission's order or voluntarily, sets up a depreciation reserve by water plant accounts, which is based upon the actual experience of the utility, the continuing property record will be found to be an invaluable adjunct especially after it has been in operation for a few years. Ratios of retirements to total cost and percentages of salvage and cost of removal as shown by the record and its supporting papers will be found very useful in establishing annual depreciation rates and allowances for salvage and cost of removal charges. In this paper I will not go into the relative merits of different methods of depreciation except to put myself on record

that I believe the determination of an adequate depreciation reserve and proper annual rates can be made by a thorough study of the records and an inspection of the property with full consideration of the management's policy, past and present, as regards expansion and growth, maintenance and replacement; and this record is going to be very helpful in making these determinations.

Another useful purpose of the continuing property record is the facility with which unit costs may be derived for estimating purposes. How many times have we used a synthetic unit price for estimating purposes and then found that the actual cost ran considerably higher without any apparent reason. Average unit costs of distribution mains, for instance, installed in any year derived from the record will include those incidental costs which are so difficult to properly include in a synthetic unit cost and which are often the cause of the under-estimate.

Of course, another major use of the continuing property record is its availability, when properly maintained, of establishing a rate base on which to recompute or check rates at frequent intervals. This no doubt is one of the major purposes of the requirement of such a record by the public service commissions. The system was designed to shorten the old procedure that first required a time-consuming and costly inventory and appraisal before hearings could be held on the rates in question.

PREPARATION AND USES OF A LIST OF RETIREMENT UNITS

By William J. Schwartz

There is a lack of uniformity in the treatment of replacements, renewals, betterments and maintenance of property which results from differences in opinion in the selection of the retirement units. State and federal governments have in most cases required uniform accounting procedure by the companies within their jurisdictions in order to insure correct and comparable data for the use of regulatory commissions. Coöperation in this work has been extended by associations of utilities as well, for not only are uniform classifications of accounts valuable to the public commissions, but to the companies in that they give smaller organizations the aid of the best accounting methods, and allow comparative analysis of conditions in different utility enterprises. It is desirable to supplement the classifications of accounts with a list of retirement units for these reasons.

Depreciation policies or retirement policies depend quite frequently on local conditions which vary considerably and for that reason the rate of wear and tear, or replacement, sale or scrapping of assets varies considerably. Therefore depreciation or retirement policies must, in the future as in the past, be left entirely flexible, to be changed as experience warrants. The list of retirement units to be adopted by a utility will depend entirely upon the sufficiency of the annual provision for the depreciation or retirement reserve. The list may have to be changed for a particular utility depending upon how often or how drastically prevailing conditions change. As an example, I might refer to the case of a utility experiencing rapid expansion, where sufficient property might become inadequate and obsolete so that the accrued retirement or depreciation reserve is wiped out. The reserve would become insufficient to take care of the retirement of small units of property unless the annual provision for retirement or depreciation were increased. A list which applies to one company should not be expected to apply to all companies,

A paper presented at the New Orleans convention, April 26, 1938, by William J. Schwartz, Controller, Hackensack Water Co., Weehawken, N. J.

even though the companies are operating in like territories; therefore, I urge on you strongly the fact that any list, which is intended to be standard, should be full and complete and should extend down to small units, but should be applied to each case individually depending on conditions.

The expenditures made in connection with plant and equipment may be classified as follows:

1. Maintenance and repairs: Expenditures which are necessary to maintain the existing tangible property in normal operating condition.

2. Additions: Expenditures made for new property which are not in the nature of renewals or replacements but represent additions to the total tangible property in use. This situation arises more particularly during periods of expansion when more buildings, extensions and equipment are needed to satisfy the demands of an increased volume of business.

3. Renewals: Notwithstanding maintenance and repairs, certain items of property must be renewed. New properties of the same kind as that which has been discarded are called renewals.

4. Replacements: Improvements and developments are continually rendering items of equipment inefficient in comparison with units of more modern design. Good management demands that the inefficient equipment be retired and replaced by the modernized machines and appliances.

5. Betterments: A situation frequently arises where property, partly inefficient or obsolete, by partial rebuilding can be made into satisfactory units of equipment. Expenditures for this purpose, that is, for bringing the unit of property up to date and thus retarding obsolescence, are frequently called betterments. In reality the expenditures are made to prolong the useful life of the units.

In distinguishing between replacements to be capitalized and repairs that should be treated as expense, the Board of Tax Appeals has taken the position that, if the replacement extends the life of the asset as a whole, it should be capitalized.

In general, following is the method for recording expenditures for property referred to above:

1. Additions to Property: Additions should be charged to Fixed Property.

2. Replacements and Renewals of Complete Units of Property: The cost of such items should be charged to Fixed Property and the

book cost of the Fixed Property replaced or renewed should be credited to Fixed Property and charged to Retirement Reserve. Where the book cost is not known or cannot be obtained, it should be estimated and the method used stated on the journal entry.

3. Replacements and Renewals of Important Parts of Complete Units of Property: The cost of such items should be charged to the Retirement Reserve either directly or by writing off the cost of the property replaced or renewed where such cost can be determined or estimated with reasonable accuracy.

4. Extraordinary Maintenance Expenditures (including betterments): The cost of such items should be charged directly to the Retirement Reserve. (Example—Guniting the embankment of a distribution reservoir.)

Items of retirement are referred to as complete units of property and important parts of complete units of property. Units of property lists have been prepared by the National Association of Railroad and Utilities Commissioners for gas and electric utilities and by the Federal Communications Commission for telephone companies. The N.A.R.U.C. is preparing a list of retirement units for water companies. The lists that have been prepared are full and complete and go down into small units, which to the writer's mind is the principle which should be used in preparing such lists. As an example, I quote from the Uniform System of Accounts for telephone companies prescribed by the Federal Communications Commission. The following are given under the heading of buildings.

A complete building

An entire roof with or without supporting members

Note A—A building of irregular shape having more than one roof level may have several isolated roofs, each of which shall be considered an entire roof. In the case of buildings to which lateral extensions have been made, even though having but one roof level, that part of the roof covering an entire section built at one time shall be considered an entire roof.

A complete fire escape

A complete metal window (i.e., box, frame, and sash)

A boiler, furnace, hot-water heater, or automatic stoker

A coal or ash conveying system

An elevator complete with operating mechanism

A gas-burner system

An oil tank

A house-lighting or power board
An oil-burner system
The floor covering for one room

A motor, generator, engine, turbine, pump, compressor, ventilating fan, air washer, elevator drum, or similar item of equipment, with or without associated wiring, control equipment, etc.

Note B—In addition to the above units of property, material, (i.e., portions of buildings, equipment, fixtures, etc.), installed and retired, and the labor and incidental costs involved in connection with work of the following character, shall be handled through the telephone plant and depreciation reserve accounts:

1. Changes in the type of operation of elevator systems, e.g., a change from manual to signal control of cars, from manual to power operation of doors, from low speed to high speed, from direct to alternating current, from hydraulic to electric operation, from one type of signaling or dispatching system to another.

2. Relocations of toilet rooms, battery rooms, kitchens, terminal rooms, machine rooms, transformer vaults, etc.

3. Structural changes such as: (a) reinforcements of floors, roofs, bearing walls, footings, and foundations; (b) additions or relocations of elevator shafts, stairways, fire exits, and vaults, but excluding switchboard cable holes and slots; and (c) building alterations required for fire protection and other safety measures.

4. Changes in the type of electric current supply, or of ventilating, air-conditioning, or similar systems.

5. Building enlargements.

6. Replacements of the following character: (a) replacements of plumbing or heating pipes (with or without associated valves) except when necessitated by minor repairs or minor relocations of fixtures; (b) replacements of all or substantially all of the lighting fixtures (with or without associated wiring and conduit) in one operating or equipment room or, in the case of office space, on one floor of a building; (c) general replacements (throughout a building or throughout an entire portion erected at one time) of items such as supply, return, or air valves in heating systems; hot or cold water valves or faucets; plumbing, heating, or drainage traps.

The writer has purposely refrained from submitting any list and recommends that the Association coöperate with the National Association of Railroad and Utilities Commissioners in promulgating a list which it is understood will be used flexibly in adapting it to each individual case.

THE PLANT LEDGER—WHAT IT IS AND WHY

By H. T. Mathews

The expression "Plant Ledger" refers to a series of related records comprising a system for the purpose of establishing an accounting control over fixed capital and retirement reserve. The plan recognizes and observes the following fundamental principles:

1. Capital investments should be recorded at original construction cost.
2. All plant, with the possible exception of land, will eventually be retired from service and should be retired at original construction cost.
3. Loss in value, occasioned by depreciation, inadequacy, and obsolescence, must be recovered through proper charges to income account, concurrently credited to retirement reserve, if the integrity of capital investment is to be maintained.
4. Satisfactory bases for use in computing retirement reserve should give effect to the variation in service life in dissimilar classes and types of property.
5. Deficiencies in reserve accumulations, ascertained at the time plant is displaced, constitute profit and loss charges.

A brief consideration of a plant ledger system for water companies, indicating the general scope of the record and the type of information contained therein, is given in this paper. It should be understood that while some modifications may be required or advantageous in cases where unusual conditions exist; the underlying principles remain unaltered.

The basic plan provides for a perpetual inventory record of all existing tangible and intangible fixed capital, operated in conjunction with an adequate system of work orders for controlling plant additions and displacements.

It recognizes the necessity of classifying plant items through the adoption of standards, sometimes referred to as "units of property."

A paper presented at the Kentucky-Tennessee Section meeting, March 22, 1938, by H. T. Mathews, Herdrich and Boggs, Certified Public Accountants, 803 Electric Bldg., Indianapolis, Ind.

Such units are established for the various classes and types of plant and furnish the basis for all plant ledger transactions. While no hard and fast rule can be applied in determining property units, a satisfactory selection presents no particular problems. Property extensions and retirements are going to take place in the future as they have in the past. It will be necessary to segregate expenditures as between capital and maintenance and it will be necessary to identify plant items when they are displaced. In order to avoid undue refinements in accounting and establish a sound practical plan of procedure the "unit of property" theory proposes to adopt a series of measures or yardsticks. Only complete units will be capitalized or retired.

Independent plant items must, of course, be recognized as individual units. This group comprises meters, meter vaults, service lines, furniture, tools, etc. There are other classes of property such as pumps, boilers, pipe lines, structures and filters that may require subdivision. It must be understood that plant will have to be separated into units if independent entries are to be made and if replacements are to be capitalized and charged to Retirement Reserve Account. This principle can be illustrated by considering a building containing a heating system or an air-conditioning plant. The building may be considered as a unit in which event a single recording will show the cost of the structure in a total figure. Suppose the air conditioning system could reasonably be expected to require renewal before the building is to be replaced. Unless this fact is anticipated at the time the record is originally prepared no adequate data will be available for determining original cost at time of displacement and the cost of replacement will have to be charged to operating expense. It therefore becomes necessary to consider the probability of replacements in connection with the question of plant units.

The record is classified and arranged in account order with proper headings. The various units of property are recorded to show dates of installation, description for purposes of identification and original construction costs.

Retirement reserves are to be accrued for the purpose of retiring complete units of property. Partial replacements are properly chargeable to operating expense. Reserve calculations take into consideration the type and class of property, estimated service life and cost. All retirement rates are recorded for reference in determin-

ing reserve accumulations for each unit of plant, thus making it possible to calculate reserve deficiencies in preparing retirement entries.

As previously stated the record contemplates the application of actual construction costs throughout. These costs may not be available in many cases. In this event the only alternative is to apply estimated original construction costs.

Some of the advantages which will result from the adoption and installation of this plan are enumerated.

1. It affords a descriptive analysis of all property and plant in service. This information may be used to advantage in the preparation of insurance schedules, income tax returns, and budget forecasts.

2. The record establishes definite standards for use in determining the segregation of future expenditures as between capital and maintenance, thereby simplifying accounting procedure.

3. It provides an equitable basis for computing Retirement Reserves and a method for testing the adequacies of retirement rates.

4. It makes possible a monthly reconciliation with primary plant account in the General Ledger since the record is balanced currently.

The necessity of obtaining factual data as to the actual construction cost of plants together with retirement policies and methods is being recognized by national and state taxing authorities and regulatory commissions. Accounting classifications recently prepared and approved by the National Association of Railway and Utility Commissioners require the installation of detailed property accounting records.

The initiative in this matter should be taken by the public utility companies. After all, it is to their interest to straighten out the record and keep it clear.

BOILER WATER TREATMENT

By P. W. Frisk

The subject of boiler water treatment has been discussed by many individuals and many of the ordinary general principles regarding boiler water treatment and the control by the various processes have been discussed in the technical literature. The author will discuss primarily the internal chemical constituents and what effect they have on boilers.

It must be remembered that there is no specific recipe or panacea which can be applied to any one or all boiler water problems. A boiler water treatment must be based on a careful study of the water used for make-up, the type of boilers, the pressure of such boilers, the load, and all the factors affecting economical operation.

Too many are apt to overlook the need for a careful study of boiler water conditioning which is proper pre-treatment and internal treatment of the boiler water. Also overlooked is the need for such treatment and analysis control by competent engineers. The result, after a short time, becomes quite obvious—a breakdown in the equipment, loss of operating efficiency, and, in some cases, a serious explosion and loss of life.

All of these difficulties can be removed by the proper application of the fundamental principles underlying boiler water conditioning.

Natural waters, either from surface or ground supply, vary in different localities. They usually contain many objectionable constituents and sludge-forming compounds. The total dissolved solids of some of these waters is such as to require a preliminary water treatment before going to boiler feed water. Where such water contains a large amount of suspended matter, it is usually necessary to coagulate and filter. Where the calcium and magnesium salts are high, a softening process is necessary. All of this precedes the internal chemical boiler water treatment. The introduction of soluble salts in the water from a treatment process may tend to aggravate

A paper presented at the North Carolina Section meeting, August 27, 1937, at Wilmington, N. C., by P. W. Frisk, Chem. Eng., Chief of Chem. Lab., America Enka Corp., Enka, N. C., and a Director of the A. W. W. A.

the corresponding constituents, which, when evaporated under pressure, results in complex scale-forming molecules.

Domestic water purification treatment plants, privately and municipally owned, cannot supply a water which will be especially suitable for every boiler purpose. The amount of such water is relatively small compared to the total domestic consumption. Therefore, it becomes necessary for each steam plant to prepare its boiler water to fit its particular conditions.

Those who are not well educated in boiler water conditioning may be led to believe by some that most boilers need only a pill or cake of magic compound to cure them of all their troubles. As a matter of fact, very few boilers can be treated successfully in this manner.

First, I wish to discuss the fundamental constituents of a boiler water, and thereby take into consideration the basic ailments, such as caustic embrittlement, scale formation, and corrosion.

The fundamental constituents which must be considered are as follows:

1. The alkalinity of a boiler water may consist of sodium hydroxide, sodium carbonate, and sodium phosphate. In the case where no free sodium hydroxide exists, sodium carbonate, sodium bicarbonate, and sodium hydrogen phosphate may exist.

These constituents compose the alkalinity, and a measure of the same may be made by titration, using standard sulphuric acid, titrating in the presence of phenolphthalein[1] and methyl orange indicators for the $NaOH$ and Na_2CO_3, and a precipitation of phosphates with $AgNO_3$, titrating the resulting products. A more reliable and quicker method for phosphates may be carried out by colorimetric methods.[2]

2. The pH (or the hydrogen ion concentration) is related to the alkalinity. The pH may be measured by one of three methods—a standard color plate, a colorimetric solution, or by a potentiometric method, using a glass cell or hydrogen electrode.

3. The total dissolved solids, which are the solids after filtering through a No. 2 and No. 42 Whatman filter paper, are the sum total of all the ingredients which may play a significant part in the conditioning of the boiler water.

[1] Sometimes methyl yellow (para-dimethylaminoazobenzine) is used to indicate total carbonate alkalinity.

[2] Colorimetric method for the determination of phosphorus. By Ch. Zinzadze, Ind. and Eng. Chem., Vol. 7, No. 4, 1935. The method as used in the Chemical Laboratory of the Amerenka is somewhat modified.

4. The total sulphates, expressed as sodium sulphate, may be determined gravimetrically, by the benzidine hydrochloride method, or by the tetra hydroxyquinone titration method. This will serve to account for a large percentage of the total dissolved solids.

5. The sodium chloride (NaCl) may be determined by titration with standard silver nitrate solution, using potassium chromate as indicator.

6. When sodium sulphite (Na_2SO_3), or its equivalent, is added to the boiler feed water, it is significant to check its content on an unfiltered sample by titrating an excess amount of standard iodine with standard sodium thiosulphate in an acid solution.

We now have covered the main constituents which should be determined at regular intervals in conditioned boiler water. Where no chemical treatment is given, some of these constituents will be lacking, but, if proper boiler water conditioning is being practiced, these constituents will have an important meaning and, when kept in the right proportion, will serve to protect the metal surfaces from scale and corrosion.

In boiler water treatment, the A. S. M. E. Boiler Code Committee[3] recommended a definite alkalinity-sulphate ratio. This recommendation was the result of data on embrittled boilers, collected by F. G. Straub, University of Illinois, 1929. This data showed that high caustic alkalinity, without the presence of sulphates, resulted in cracking. This committee set up the following ratio for various pressures:

Pounds Working Pressure	*Ratio of Alkalinity to Na_2SO_4*
0–150	1/1.0
150–250	1/2.0
250-Over	1/3.0

It is interesting to note that those boilers which were fabricated during the World War have resulted in the majority of boiler failures. This would tend to indicate that the failure was partly due to poor materials and to the rush of war orders.

The present materials fabricated for boiler purposes have a considerable advantage, since it is possible to X-ray boiler drums and tubes to detect flaws and imperfections. This careful check-up on the material may greatly reduce the number of failures in the future, due supposedly to caustic embrittlement.

[3] Embrittlement of Boilers, Bulletin No. 216, Eng. Exp. Station, University of Illinois.

To counteract complex scale-forming molecules, such as the formation of analcite scale ($Na_2O \cdot Al_2O_3 \cdot 4\ SiO_2 \cdot 2\ H_2O$) an internal boiler water chemical treatment is necessary. Here is where the phosphates and the alkalinity of the boiler water play an important rôle. Phosphate salts of calcium and magnesium are very insoluble in alkaline solution in the presence of an excess of soluble phosphate radical. The sodium alkalinity tends to keep the silica in solution. A high hydrogen ion concentration of 10.5–11.0 keeps the silica in solution. A high pH value with tri-sodium phosphate insures maximum solubility of silica, preventing the formation of analcite. As reported by R. E. Summers and C. S. Keevil,[4] the calcium and magnesium phosphate, in the presence of a high pH, carry a large amount of silica from the boiler water blowdown.

The factor causing corrosion is the presence of oxygen and carbon dioxide. If a proper deaerator is maintained with the addition of sulphite and the maintenance of the proper pH, corrosion will be eliminated. The sulphite addition may also serve to balance the alkalinity-sulphate ratio.

The author will not go into a detailed discussion of other major factors affecting boiler efficiency, except to mention these facts in a general way.

In the discussion of the type of boilers, either stoker or pulverizer, the economy is based upon the initial installation cost, fuel cost, and load. The load takes into consideration whether the boiler is continuously or intermittently operated, and whether the boilers are banked and held as an auxiliary unit. For economical operation, it must further be considered whether such boilers produce steam for electric power generation only or whether it is partly bled from turbines to lower pressure steam, which may be used for factory heating or processes, etc. The type of boilers will affect the type of chemical treatment and the load will affect the way in which a chemical dosage should be given to the boiler water. The pressure will require the consideration of the sulphate-alkalinity ratio, if the A. S. M. E. Code is followed.

The surface waters of western North Carolina are soft, considered 7.0 p.p.m. $CaCO_3$, and have a relatively high percentage of silica to the total dissolved solids present.[5] This type of water, coagulated

[4] Power Plant Engineering, May, 1934.

[5] Economic Paper No. 61, N. C. Dept. of Conservation and Development, Table No. 15.

with aluminum sulphate, presents a problem of analcite scale-forming materials in boilers.

Well waters of western North Carolina are relatively high in hardness and require an external dehardening treatment, in addition to an internal boiler water treatment.

To sum up the major factors in boiler water conditioning:

1. It is necessary to know the composition of the boiler feed water.
2. The services and counsel of experts who have made a study of boiler water conditioning and who have had experience with all types and combinations of conditions should be obtained.
3. The necessary chemical (external and internal) water equipment must be installed to properly condition the water.
4. The dosage must be controlled by definite chemical procedure and analysis.

DEVELOPMENTS IN SOIL CORROSION AND PIPE PROTECTION

By F. N. Speller and V. V. Kendall

The stability of structures buried in the soil has been the subject of intensive study, particularly by the oil and gas industry. A résumé of their large-scale investigations and of recent developments shows many points of application to the water works field.

In contemplating the subject, it has been helpful to associate all soil corrosion with electrolytic action regardless of whether the current producing or preventing the corrosion comes from an electric power plant or if generated in the soil. The conditions prevailing in the soil determine the extent and intensity of corrosion. It is difficult to classify definitely a soil as corrosive or non-corrosive because of the many more or less interdependent factors involved. In general, for a definite water content, the corrosivity can frequently be gaged by the electrical conductivity and the total acidity or alkalinity of the soil. Based largely on the National Bureau of Standards' investigation during the past twelve years, soils can now be surveyed, with respect to their action on metals, with considerable accuracy (80 to 90 per cent in some cases).

Dr. Denison of the Soil Corrosion Division, National Bureau of Standards (3), has made the following classification of soil factors:

Factors inducing corrosiveness	*Factors retarding corrosiveness*
Poor aeration	Good aeration
Fine or close texture (clay)	Coarse and open texture (sandy)
High average moisture content	Low average moisture content
Low electrical resistivity	High electrical resistivity
Acidity: (a) high hydrogen-ion concentration; (b) high total acidity	Alkalinity
Presence of sulphides	Presence of calcium carbonate
Reduction of sulphates by anaerobic bacterial action	Presence of soluble silicates

A paper presented at the New Orleans convention, April 28, 1938, by F. N. Speller, Advisory Engineer, Dept. Metallurgy and Research, National Tube Co., Pittsburgh; and by V. V. Kendall, Dept. Metallurgy and Research, National Tube Co., Pittsburgh.

The pitting rate in coarse-textured soils, although initially higher than in fine-textured soils, slows down due to the oxidation and precipitation of corrosion products in contact with the surface. Dr. Denison comments on this classification as follows:

"Although the various factors listed above influence corrosion as indicated, no single factor is necessarily associated with corrosive or non-corrosive soils. For example, alkalinity has an inhibiting effect on corrosion, but some alkaline soils are among the most corrosive soils with which we have to deal. This is because alkalinity in soils is often associated with high concentrations of soluble salts, the latter having the determining effect on the rate of corrosion. Similarly calcium carbonate has a retarding effect on corrosion, but poorly drained soils containing an abundance of lime are usually corrosive. Finally, I might cite the case of well drained acid soils which are relatively non-corrosive although acidity is definitely a corrosive factor."

It is true also that high alkalinity, below that required to entirely prevent corrosion, tends to increase pitting.

From time to time the National Bureau of Standards has held a Soil Corrosion Conference for the exchange of information by those engaged in soil corrosion and coating investigations. The fourth Conference was held in November, 1937. About eighty papers were presented, twenty-two of which were from foreign countries. Although the papers and discussions were originally confidential, quite a number of the papers have been, and will be, published (16–29). A summary of the conference has been published (5) and a more extended correlated abstract is being prepared (8).

The large-scale study of soil corrosion by the National Bureau of Standards and investigations by other agencies have developed the following general conclusions of practical importance:

1. All commonly employed metals corrode in certain soils and all require protection in severely corrosive soils. Soils vary greatly in their corrosivity, depending upon their physical and chemical properties.

2. The range of content of carbon, manganese, sulphur, silicon, or copper found in commercial grades of carbon steel and iron shows no indication of having a very material effect on the corrosion rate of the metal. Cast iron corrodes mainly by so-called graphitization and, when this occurs, the depth of penetration in cast iron has been found greater than in steel in the same soils.

3. Copper is corroded by soils high in organic matter and by alkaline soils in which the ratio of chlorides and carbonates to sulphates is high. Serious corrosion of copper is likely to occur in cinders and tidal marshes. Copper is cathodically protected when in contact with iron in moist conductive soil, and corrosion of the iron is increased proportionately.

4. The corrosion of lead is practically negligible in soils high in sulphates and carbonates. It takes the form of pitting in soils that are about neutral in reaction (pH 7) and which contain very little soluble material, especially sulphates. In soils containing organic acids the attack is much more uniform and the rate of penetration is rather low.

5. The effectiveness of zinc coatings and the poor protection afforded by lead coatings on steel is primarily due to the fact that zinc is anodic to steel and lead is cathodic. Hot galvanizing shows a slower rate of corrosion than pure zinc and reduces corrosion of the base metal by 50 to 90 per cent, depending upon the soil.

6. The rate of pitting in poorly drained soils is approximately proportional to time, regardless of the metal used. In well-drained or well-aerated soils, the rate decreases with time. In such soils, increasing the thickness of the pipe a small amount will increase its life a considerable amount.

7. The most important factors in soil corrosion, aside from water content, are the total acidity or alkalinity, and the electrical conductivity.

8. Recent investigations in Holland (10) have shown that under certain conditions bacteria in the soil are indirectly responsible for serious corrosion. Those conditions are: the absence of air, the presence of sulphates, and the presence of assimilable organic compounds. The bacteriological process in soil corrosion has been shown to be essentially the same in principle as in corrosion in water. The bacteria obtain their oxygen by reducing the sulphates in the soil, and some of this free oxygen combines with the hydrogen on cathodic areas and thus corrosion occurs in the absence of air. This process also applies to organic, peat, or mucky soils, but these are not so prevalent in this country.

The conditions to which pipe is exposed in distribution systems are, in general, more severe than those encountered in long pipe lines. The soil in a city, except when a community is first being built up, is of no definite type. It is continually being disturbed,

mixed with soil from other locations, with refuse, cinders, etc. These conditions grow more severe with time. The National Bureau of Standards' investigation shows that natural soils vary tremendously (at least 40 to 1) in their corrosivity and that, with most soils, a given type of soil is roughly associated with a given range and type of corrosivity. However, only the general facts developed from these data can be applied to the specific conditions within the city. The corrosivity of city soil may be judged from the repair records of mains and services. Generally, only certain low areas of city soil are very corrosive.

PROTECTIVE COATINGS

Bituminous materials have been most generally used for underground pipe coatings. Field tests have indicated that many of these coatings were far from satisfactory in certain soils.

To outline the requirements of a suitable bituminous protective coating for pipe buried in the ground is not difficult; to fulfill those requirements is quite another problem. Nevertheless a statement of such requirements concentrates and limits the problem. These requirements may be listed as follows:

1. The coating must adhere uniformly and tenaciously to the entire metal surface.

2. It should be preferably a good electric insulator, preventing the flow of low voltage currents to and from the pipe.

3. The coating should be impervious to water and not affected by the soil or ground water. It should be of such a nature that, should water penetrate to the metal surface, any reaction of the water with the metal surface would be prevented or stifled. Water, for example, can penetrate cement coatings but, due to their alkalinity, corrosion is inhibited.

4. Mechanically, it should not flow under stress (i.e., it should resist soil stress), should not crack or become brittle at lower temperatures, or soften and flow at higher temperatures.

5. It must be economical. The economy will vary with the type of coating used, which in turn is dependent upon the severity of attack of the soil to which the pipe is exposed. This is primarily an engineering problem which requires the consideration of various factors such as: the expected useful life and importance of the pipe line, the original cost, the probable life of bare pipe and the life of available coatings, the cost of coatings, the cost of renewing vs.

reconditioning of the line, and the loss and damage from leaks. All of these factors must be evaluated and the answer obtained for each pipe line.

6. The coating must be sufficiently thick to adequately provide for the requirements listed above under 2, 3, and 4. The American Gas Association and American Petroleum Institute tests on coatings have shown that a thickness of bituminous coatings of at least 0.10 inch is necessary in corrosive soils.

The bituminous materials available to meet these requirements are coal tar and asphalt. These may also be modified by inert fillers and reinforced by various fabrics. Vitreous enamel and miscellaneous materials, such as synthetic resins and rubber, have been, or are being, tried.

It is well known that portland cement has been successfully used for 40 or 50 years on oil pipe lines where the soil water does not attack cement. Cement may be applied to a damp metal surface that is free from grease and loose foreign matter. When more electrical resistance is desirable, the cement mixture may be applied over a suitable bituminous coating. Particular attention should be given to coating the bottom of the pipe to avoid air pockets or other defects, since corrosion is more likely to occur on the under side.

PREPARATION OF THE METAL SURFACE

No coating, however efficient, will fulfill its function if improperly applied. Bitumens and paints must be completely bonded to the metal. Of course, this requires a clean dry surface. There are, however, other factors that influence adhesion, such as roughness of the surface and absorptive properties of metal surface films. The interaction between the different layers of the coating is also of considerable importance.

The application of a coating over mill scale is a question about which there has been considerable controversy. Much of the mill scale adheres to steel more tightly than do organic coatings. The bond is often over several thousand pounds per square inch, which is far above the cohesive strength of bituminous coatings. Any loose scale or other foreign matter should, of course, be removed before applying a coating. Blasting with sand or steel grit may increase the surface area at least ten times, depending upon the size and shape of the particles. This enlarged surface increases adhesion, provided the coating is applied after cleaning before mois-

ture or rust forms on the surface. It is questionable if there is any advantage in improving the bond of the coating to the metal much beyond the cohesive strength of the coating itself. Coatings may have a good bond to the metal when first applied, but may be loosened when water finds access to the metal or when reactions occur, as they sometimes do, between the primer and the outer coat.

The main argument against coating over firmly attached mill scale seems to be that the scale may be loosened by corrosion, the mill scale being slightly cathodic to iron. This is not likely to occur where a thick waterproof bituminous coating is used, or where the metal is rendered passive by an inhibitor, or insulated from the mill scale by a highly resistant priming coat.

Where the metal inside of a steel water main was covered with an alkaline cement mixture, the mill scale was found firmly adherent to the metal after fifty years in service. So, with thick coatings, it is very doubtful whether there is any advantage in spending money on removing other than the loose scale. This may be economically accomplished with mechanical impact appliances made for the purpose, and can be more effectively done after weathering. Where thinner coatings are used, a more satisfactory job can probably be obtained by scouring off all loose scale and applying a very durable primer to which bitumen will adhere. A few synthetic paints, usually containing over 25 per cent zinc chromate, have been found to protect steel for at least four years in water. Such paints (particularly on an inhibited steel surface) may add considerably to the life of bituminous coatings.

Sand blasting by hand has been done on large jobs at a little less than two cents per square foot. By mechanical means, the large steel pipe for the Los Angeles Aqueduct was grit-blasted free of scale inside and outside at approximately one-half cent per square foot, but it has been estimated that if the outside only were cleaned in this way, the cost would have been considerably higher. (See (13) for a more detailed discussion of metal surface preparation.)

The large-scale investigations of pipe-coating materials conducted by the National Bureau of Standards, American Gas Association, and the American Petroleum Institute, have produced much useful information (30–37). Since space does not permit a detailed discussion of this information, we shall attempt to assemble only the general conclusions and the reader may consult the references in the bibliography for more details. A considerable amount of the

pipe in the oil and gas industry is laid without any coating. This, however, includes pipe laid in accordance with the practice of some companies of installing it bare and then reconditioning the "hot spots" as they develop. Several steel water mains have given 40 years of service with only a hot-dip coating. For example, the Newark City 48-inch water supply line was laid in 1896 of $\frac{1}{4}$-inch riveted steel (1). It was recently reconditioned by cement lining. This line was originally given a horizontally asphalt-dipped coating. The outside had suffered very little corrosion and the maximum depth of pitting on the inside was not over $\frac{1}{8}$ inch. Many examples of steel mains of long life can be given. A list of over one thousand installations of steel pipe 20 inches or over in diameter, which were installed from 1871 to 1935, is given in the "Report on Steel Pipe Lines for Underground Water Service" of the Underwriters' Laboratories (15).

Thin bituminous coatings under .02 inch are of very little value. These coatings, such as single dips, cut-backs, and asphalt emulsions, have some value, however, in reducing the area of pitting. The thicker the coating, the more effective and, of course, the more expensive it becomes. The lower limit of thickness that should be used is believed to be about $\frac{1}{16}$ inch. If any coating is justified or necessary, it should be at least this thick. The upper limit of thickness is more variable, depending upon the cost of coating material, the corrosiveness of the soil, and the cost of repairing leaks, but it is rarely over $\frac{3}{16}$ inch for reinforced bituminous materials.

The coal-tar base materials are more stable and moisture proof, but they have a greater tendency to flow when warm and to crack when cold than do the asphalt-base coating materials. However, corrosion does not always follow water absorption. Dr. Ewing (4), after a long study of these materials in old pipe coatings, concludes: "The choice between asphalt and coal-tar base materials depends upon relative costs. Both materials have advantages and faults, and good coatings can be made from either material."

Whatever the difference in durability between asphalt and coal tar, it would seem that this becomes of less importance and is of no practical significance when thick reinforced bituminous coatings are applied. Good blown asphalt costs less than one-half the price of high grade coal-tar pitch and, therefore, much more could be used at the same cost.

Any organic reinforcement incorporated in a coating may be a

weakness, especially if the bitumen is an asphalt. Such materials should be thoroughly saturated and deeply imbedded in the bitumen, but not in contact with the metal. There should be $\frac{1}{16}$ inch of bitumen under the fabric. In Australia they impregnate Hessian fabric with coal tar and run it through a wringer before wrapping. This coating is $\frac{1}{4}$ inch thick.

Shields and reinforcements enhance the value of most coatings by protecting them during the backfill and the subsequent settling period, and against soil stress. The additional thickness may also be a favorable factor. Asbestos felt offers more permanent reinforcement to bituminous materials than rag felt.

Bituminous primers should be of the same type of bitumen as the coating which follows, i.e., asphalt primers are not suitable for coal tar nor coal tar for asphalt enamels. The bitumen of which the primer is made should have nearly the same physical properties as that used in the outer coating.

The performance of a protective coating is controlled largely by the soil conditions to which it is subjected. The shrinkage and the relative density of the soils are important factors in the distortion of coatings. Distortion is especially severe in dense soils which undergo marked changes in volume with change in moisture content. Therefore, coatings should be selected with reference to the soil conditions to which they are to be exposed.

Since the National Bureau of Standards' tests were started, new coatings have been introduced. The coal-tar industry has developed an improved product, the so-called "plasticised" coal-tar pitch. Enamels made from this pitch are reported to withstand temperatures at 160°F. continuously for 24 hours or more without sagging, and 10° below zero without cracking, and to have a ductility approaching that of asphalt coatings (7). As coal-tar pitch absorbs less water and is somewhat more durable than asphalt, the new plasticised variety should be useful, provided (as seems probable) it proves to be nearly as durable in service as the older product.

The durability of asphalt coating material can be considerably increased by suitable fillers. Strieter (14), as the result of weathering and accelerated tests, found that the addition of talc, mica, and peach bottom slate up to 35 per cent by weight, improved durability. Less positive results were obtained with silica, trap rock, dolomite, and limestone in amounts of 15 per cent. Hydrated lime was the

only filler tested that did not increase the durability of the coatings, the 35 per cent filled material having lost its adhesive property. Particle size and distribution of the filler are also a factor. It was found that fillers passing a No. 100 sieve, but retained on a No. 200 sieve, produce better coatings than fine filler, all of which passes a No. 200 sieve.

In the heavy mastic-type coating, considerable improvement in water resistance and in tensile strength has resulted from the use of finer filler material and the addition of a small amount of asbestos fiber. Such mastic is now extruded $\frac{5}{8}$ inch thick directly on the pipe, and has proved to be very satisfactory on hot oil lines in California.

SPECIFICATIONS

Soils differ so greatly in their effect on metals that the formulation of a coating specification that would attempt to apply in detail to all soils would be both technically and economically unsound. Many soils have little effect on metals but a light coating may be desirable if it is thought that cathodic protection might be necessary at a later date. Specifications should, therefore, be drawn to apply to soils of different degrees of corrosivity. Furthermore, the availability or low cost of a particular material may result in its use in certain localities to the exclusion of other materials.

In Holland, standard specifications have been written covering four types of blown asphalt coatings, varying in thickness and cost. Later on, they expect to write specifications for coal-tar coatings. In Australia, coal tar is used.

For inside protection against corrosion and tuberculation a spun lining of bituminous material with a minimum thickness of about 0.10 inch is now generally used here and abroad.

Cement lining has a long and satisfactory record for water pipe and has recently been applied in reconditioning the inside surface of water mains in service.

The Bureau of Water Works and Supply of Los Angeles (7) is using the "plasticised" coal-tar material (mentioned above) for pipe coating. Their pipe-coating specification is worth reviewing. The pipe is sand-blasted or grit-blasted (using No. 50 or No. 60 steel grit). Primer, applied by air-spray gun, is allowed to dry for not less than 24 nor more than 72 hours, and the coating applied to a finished thickness of $\frac{1}{8}$ inch on the inside and $\frac{1}{10}$ inch on the outside. The

interior coating is applied by the centrifugal casting method and the exterior coating may be applied by hand-daubing, pouring, and wiping or other approved methods.

After testing by the electrical brush method and repairing pinholes, the pipe is given a coating of whitewash. This whitewash consists of a mixture of quick lime, water, salt, and a vegetable oil plasticiser. Its purpose is to prevent the coating from absorbing solar heat and to keep the soil from bonding to and rupturing the coating by soil stress. The Colorado River Aqueduct was coated on the inside with a $\frac{3}{32}$-inch coating of coal-tar enamel centrifugally applied. This pipe was 11 ft. 6 in. in diameter. Before this project, the largest pipe centrifugally lined was 78 inches. The outside received a coating of coal-tar enamel $\frac{3}{32}$ inch thick following by a reinforced $\frac{3}{4}$-inch gunite shield for very corrosive soils. Sometimes gunite coating alone was used for slightly or moderately corrosive soils. The coating practice developed by the engineers of the Los Angeles Aqueduct System marks a distinct and important development in the art.

CATHODIC PROTECTION

Cathodic protection which has been recently developed for oil and gas lines is now being extended into the water works field (35–37). A recent example is the Mokelumne Aqueduct reported by Knudsen (9), which covers a distance of about 94 miles, 71 of which are buried. Originally installed in 1928 with a bituminous dip coat and spirally wrapped felt covering, its condition after three years was such as to indicate that protective measures were necessary if serious corrosion was to be avoided. Cathodic protection was installed, and calculations indicate that cost of cathodic protection was far below the cost of recoating the line with an adequate coating.

TRENCH FILL

Mechanical damage to coatings by soil stress and movement of the pipe on a rough foundation has been frequently discussed. However, the fill material may have other influences on bare or on coated pipe. We have shown experimentally that inert sediment of uniform thickness on metal greatly slows down the rate of corrosion in water (12). The finer the particle size the greater the protection afforded. Burns (2) has reported similar observations from his work on corrosion of lead.

On the other hand, deposits of irregular density or composition, such as clods of clay, cinders, roots of trees, etc., have a strong tendency to localize corrosion by creating marked anodic and cathodic areas on the metal.

For about twenty years, steel water pipe in cinder fill in the steel mill yards has been successfully protected by applying about $\frac{1}{32}$ inch of hot bitumen and puddling 6 inches of wet weathered clay (free from soluble salts) tightly around the pipe in the trench. Where the drainage is good, the coated pipe may be laid in and covered with 6 inches of sand. This method was used in laying the 54-inch steel main that supplies the new Irvin Works of the Carnegie-Illinois Steel Corporation, near Pittsburgh, Pa. Pipe with a strong outside coating of concrete applied by guniting about 1 inch thick does not require such precautions in back-filling. However, the influence of the composition and properties of trench fill should be more generally recognized and controlled.

CONCLUSION

The informal conferences on soil corrosion and protective coatings held from time to time by the National Bureau of Standards have been of considerable benefit both in making available new data and in stimulating thought and research.

The most important developments or trends in pipe protection in the water works field are: the general application of portland cement concrete or spun bituminous coatings for prevention of corrosion and tuberculation on the inside of water pipe; improvements in details of instruments and methods of surveying soils for their corrosivity and for stray currents; and the use of better and thicker coatings and improved means of application. Reconditioning of old pipe lines is now more economical and more widely applied in the oil and gas industry.

Cathodic protection has now been successfully used for ten years to protect gas mains. In most cases, by this means field lines and often city lines can be economically saved if protective coatings should fail. The possible application of cathodic currents to water mains should be investigated and provided for in the original design of the system, where there is a chance that it may be needed to give permanent protection.

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Discussion by HURLBUT, HAYES, and GOIT.* We should like to present the following comments upon the paper by Messrs. Speller and Kendall, particularly on certain items about which our opinion differs from the authors'.

The subject of soil corrosion is very thoroughly covered. Our experience with cast-iron pipe verifies the statement that "cast iron corrodes mainly by graphitization." Many miles of cast-iron pipe have been removed in Los Angeles, because of obsolescence of size, and placed in other locations after cleaning. Practically the only cast-iron pipe removed due to corrosion has been found to be graphitized. The generalization that "only certain low areas of city soils are very corrosive" must not be taken too literally. Some of our most severe areas in respect to graphitic corrosion are near the top of well-drained slopes where the soil is virgin and dry enough to make hard digging.

Messrs. Speller and Kendall state that coatings "may be loosened when water finds access to the metal or when reactions occur." This we believe in general is true, but we find, with our coal-tar enamel and primer, that the bond is actually stronger after a year or so in service than when first applied.

In regard to coatings over mill scale surfaces, we have found that even with a heavy coat of good paint, scaling off of the mill scale is a continuous process. With mechanical cleaning of any kind other than complete removal by sand blasting, we are never sure that all loose mill scale has been removed.

As regards the use of synthetic paints under a bituminous coating, this may be a satisfactory practice with asphalts, but it should not be done with the type of coal-tar enamel that we use. The primer has to be designed specifically for the enamel to obtain the performance we require, and any other material interposed would impair the combination.

Referring to the mention of our costs of sand blasting steel pipe, perhaps our previous correspondence with the authors on this subject was misleading as regards the relative cost of cleaning one surface of pipe only in comparison to cleaning both sides with one operation. If one side only were to be cleaned, the two banks of nozzles now used

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for two sides would be concentrated on the one side, and the speed of movement of the pipe practically doubled. Thus the cost per square foot for one side only would be but slightly higher than for two sides done simultaneously. We use the general term "sand blasting" quite loosely at times. Our mechanical blasting plant uses steel grit which is made by crushing chilled shot to produce small sharp pieces of the chilled steel.

In reference to the difference in durability between asphalt and coal tar, it has been our experience that all asphalt coatings, even blown asphalt with a mineral filler, will blister in three to five years under continuous immersion or in damp soils. Asbestos felt wrappers and additional coats only somewhat extend the life of the asphalt.

Guy Corfield of the Southern California Gas Company has made water absorption tests on practically all available protective coating material,[1] and the data thus obtained, correlated with field experiences, show that with soil conditions and other things being equal, the service life of a material is proportional to its resistance to moisture penetration. In a graph of typical water absorption rates for these materials, the lowest ratio between asphalt and coal tar is about five to one. We have records of enamel that has been on tanks for twenty-five years, and is still in service. In this connection, the probable durability of the new plasticized pitch-enamels should be equal to that of the old type pitch-enamels, as their water absorption curves follow that of typical coal tars.

As regards specifications for varying soil conditions, it has been our practice to write one specification to cover all conditions of service. We have found that, with the material we use and the method of application and installation, we get the lowest cost protection that we can buy, and it is satisfactory for either mild or severe conditions. The only variations in the specifications are: (1) a softer enamel is permitted for inside spinning than for outside coating and (2) screened or sand backfill is required for the most severe locations.

We feel that this paper by Messrs. Speller and Kendall is a worthy and up-to-date contribution to the water works field and to protective coating practices. What differences of opinion we may have, arise largely from our leanings in favor of coal-tar enamels.

[1] "Soil Corrosion Investigations and Procedure in Los Angeles" by Guy Corfield, et al., Los Angeles Gas & Electric Corp., presented at the third Underground Corrosion Conference, National Bureau of Standards.

Discussion by SPELLER. With reference to discussion by Messrs. Hurlbut, Hayes, and Goit, we note the favorable experience reported with coal tar base coatings in their locality. This might not be the case in other localities where a much greater difference in temperature and other conditions prevails. Oil pipe lines are now generally protected with reinforced asphalt coatings and, so far as we know, no trouble has been experienced due to blistering of the coating.

Regarding the use of modern water-resisting synthetic paints (such as those made up with a phenolic resin base) which, in our experience, have shown no deterioration after 4½ years' immersion in water, it is not necessary, nor was it our thought, to apply the hot bitumen directly on this base coat. The bituminous primer preferred should be applied on the synthetic base paint. If further improvement in adhesion is necessary, the synthetic primer, after drying for about ten minutes, may be dusted with very finely ground silica.

It is interesting to learn now that with the nozzle arrangement described, the cost of grit blasting the exterior of pipe is only slightly in excess of that reported where both the inside and outside were cleaned together with the convenient layout designed for the Los Angeles Aqueduct job. We quite agree that it is preferable to remove all the scale prior to coating for permanent jobs when this can be done so economically, but there is still a considerable difference of opinion as to the necessity of this expense when thick bituminous or portland cement coatings are applied. Relatively little complete descaling is now done on oil and gas lines prior to coating.

MICROSCOPIC GROWTHS IN DISTRIBUTION SYSTEMS AND THEIR FOOD SUPPLY

By A. M. Buswell

The question of the growth of non-pathogenic organisms in distribution systems has been a troublesome one for many years. It has long been recognized that the presence of iron, manganese or hydrogen sulfide would stimulate the growth of a variety of organisms capable of using such materials as sources of energy. The iron precipitating bacteria have been rather extensively studied,* and somewhat less attention has been given to manganese and hydrogen sulfide forms. These organisms are not as well known as we should wish. Two factors are responsible for this condition. In the first place they are not connected as far as we know with any disease conditions hence they have not been the object of study by the large group of medical bacteriologists and not being of any apparent beneficial economic value they have not been studied from that standpoint. The second factor limiting the study is the fact that these organisms cannot usually be grown under artificial conditions. Hence they have not been attractive material for the taxonomist.

The writer has an uncomfortable feeling that none of the classifications are above question. However there are certain fairly well defined forms which can be identified with reasonable certainty.

All living organisms must have available some food supply which is capable of yielding energy through chemical reaction. This energy is required for the growth and activities of the organisms. Throughout the animal and vegetable kingdom this supply of energy involves, with a very few exceptions, the chemical element carbon. Green plants can use the radiant energy from the sun to build up food from carbon dioxide and water. Animals and a large group of microscopic

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A paper presented at the Illinois Section meeting, April 5, 1938, at Decatur, Ill., by A. M. Buswell, Chief, State Water Survey Div., Urbana, Ill.

* Complete bibliographies will be found in "Iron Depositing Bacteria and their Geologic Relations" E. C. Harder, U.S.G.S. Prof. Paper 113 (1919) and "Biologie des Eisen-und Mangankreislaufs" Paul Dorf, Verlagsgesellschaft fur Akerbau Berlin (1935).

organisms known as saprophytes obtain energy by burning the substances built up by plants; namely sugars, fats, etc. In this latter group the energy comes from the slow burning or combination of the carbonaceous material with oxygen.

Since the group of organisms in which we are interested was found to develop under conditions where oxidizable carbonaceous material was absent and where no radiant energy was available it occurred to early bacteriologists to look for energy from the oxidation of inorganic substances. This search revealed the fact that wherever these organisms occurred one encountered iron, manganese or sulfur in an unoxidized form. These forms of iron, manganese and sulfur were capable of combining with dissolved oxygen in the water either with or without the presence of bacterial catalysts with the evolution of energy as indicated in the following equations.

$$2\,FeCO_3 + H_2CO_3 + O = Fe_2(CO_3)_3 + H_2O - 22{,}000\ Cal.$$
$$S + 1\,1/2\,O_2 + H_2O = 2\,H^+ + SO_4^{-} - 17{,}650\ Cal.$$
$$H_2S + O = H_2O + S - 80{,}010\ Cal.$$

We might remark that when reactions such as the above occur some of the energy must necessarily go into heat but the remainder is available for doing work and is referred to as free energy. Where data are available for calculating free energy, this value should be used for measuring the availability of a substance for bacterial life. Where data are not available, an approximation can be made by calculating the heat of combustion.

One would expect that if the food supply of the bacteria were removed their growth would be stopped. With this in mind, iron removal plants have been quite widely installed and we may say with uniformly beneficial results. However in some cases growth of organisms similar to iron bacteria has persisted even after the very complete removal of iron. To remedy this situation, chlorine has been applied before the filters, in the filters and after the filters and in some cases relatively enormous dosages of chloramine have been used. In spite of these precautions these saprophytic growths have persisted.

Many of you will remember that Mr. W. F. Monfort, Miss Margaret Perry and Mr. Barnes studied this problem in 1918 and 1919. In discussing these studies with Miss Perry in 1920, my attention was called to the fact that many of our Illinois well waters contain appreciable amounts of ammonia and that it was possible that ammonia

might serve as a source of energy. That this presumption is correct is shown from the following equations for the energy available from the oxidation of ammonia to form a variety of products.

$$NH_4^+ + 2\,O_2 = 2\,H^+ + NO_3^- + H_2O\ (1) - 81{,}230\ \text{Cal.}$$
$$NH_4^+ + 3/2\,O_2 = 2\,H^+ + NO_2^- + H_2O\ (1) - 63{,}230\ \text{Cal.}$$
$$NH_4 + 3/4\,O_2 = H + 1/2\,N_2 + 3/2\,H_2O\ (1) - 86{,}670\ \text{Cal.}$$

Further confirmation is given by the fact that there is an appreciable conversion of ammonia to nitrite as these waters pass from the filter plant to the distant portions of the distribution systems. A further interesting calculation indicates that the energy in the ammonia in a million gallons of the University water supply would be sufficient to produce 40 pounds of bacterial growth dry weight. This material would yield 800 pounds of wet sludge of 95 per cent moisture content.

Among the possible sources of energy we must list methane since it occurs in many of our iron-bearing waters. Although methane using organisms are known,** we have no evidence at present that they exist in our waters. The energy from methane oxidation is very large:

$$CH_4 + 2\,O_2 = H_2O + H_2CO_3 - 192{,}570\ \text{Cal.}$$

The presence of ammonia and methane seems to the writer to provide only a partial explanation of the situation encountered. The large amounts of chlorine which have been used should, we believe, have resulted in effective disinfection and we have been inclined to look for a possible source of reinfection in the distribution system. Naturally cross connections of any sort might produce such reinfections. At this point we wish to call attention to the fact that fire hydrants during the time when they are not in use present an ideal habitat for the exact type of organisms which plague some of our distribution systems. It is a common belief that water will not flow uphill but those who have studied hydraulics are well aware that eddy currents may be set up which would carry material against high flows. We wish merely to raise the question here as to whether the occasional opening of fire hydrants may not result in the infection of a water system with saprophytic organisms.

Chlorine is, of course, our standard panacea in spite of the disagreeable odors and tastes which its excessive use produces. Chlor-

** Buchanan and Fulmer, *Physiology and Biochemistry of Bacteria*, p. 221, Williams & Wilkins, 1930.

amine would apparently not be advisable since it breaks down to form ammonia which in turn may be used for food by bacteria. The removal of iron, manganese and hydrogen sulfide is of course to be employed wherever these substances are present.

A combination of iron removal with water softening makes it possible to depend on chemical rather than bacterial means for iron removal and the filter bed can be kept in much better condition. This removes one of the most serious points of infection.

The removal of ammonia has not been attempted in water works so far as we are aware. At the present time two possible means appear open. The addition of phosphate along with softening reagents will result in the formation of a certain amount of calcium and magnesium ammonium phosphate. A few preliminary experiments along this line have not been particularly encouraging. The second method is the use of the recently developed acid organolites. Suffice it to say that these contact materials are capable of taking up ammonia and sodium in addition to calcium and magnesium.

An experimental organolite filter is in operation in the State Water Survey laboratory in Urbana for the purpose of determining whether or not ammonia can be efficiently removed in this manner. It is known that ordinary zeolite will take up ammonia under certain conditions but the use of these minerals for that purpose has not been very extensive.

THE CHICKASAW, ALABAMA FILTRATION PLANT

With Particular Reference to Color Removal and Corrosion Problems

By A. Clinton Decker and J. E. Jagger

In 1917, when the shipbuilding plant of the Chickasaw Shipbuilding and Car Company (Subsidiary of the United States Steel Corporation) and the village of Chickasaw adjacent to this plant were being developed, a water supply system was constructed to furnish domestic water for the village and plant as well as for boiler purposes at the latter.

The source of supply was Eight Mile Creek, a stream originating in the vicinity of Springhill and fed largely by springs, so that the flow was at a reasonably uniform rate. Stream gagings, made at the time, indicated a minimum flow of more than twenty-five million gallons per day. Immediately after rains there were substantial increases in quantity of water for relatively short periods of time. The water was normally very low in turbidity but quite high in color, the latter condition being indicated by the local designation of the stream as "Red Creek."

Because of the normal clarity of the water and the fact that periods of turbidity were of only short duration, it was decided to design initially for only plain sedimentation which was provided for by the construction of a storage and settling reservoir having a capacity of one million gallons and consisting of two concrete basins each having a capacity of one-half million gallons. Disinfection was accomplished by use of one semi-automatic chlorinator, with a standby manually operated unit. Water was pumped into the settling basins by means of low lift pumps and from the settling basins by means of high lift pumps to the distribution system, on which was located a 200,000-gallon elevated steel tank. During periods of high turbidity in the creek, the low lift pumps were not operated and water was

A paper presented at the New Orleans convention, April 27, 1938, by A. Clinton Decker, San. Eng., Tennessee Coal, Iron and Railroad Co., (Subsidiary of U. S. Steel Corp.), Birmingham. Ala., and J. E. Jagger, Vice-Pres. and Ch. Eng., Alabama Water Service Co., Birmingham, Ala.

drawn from the storage and settling reservoirs. When turbidity persisted for such period of time as to exhaust the entire available water in one unit of this reservoir, the high lift pumps were switched over to the other unit and the low lift pumps operated to fill the first unit where the water had an opportunity to settle while water for the distribution system was being drawn from the second unit of the settling basin.

Sometime subsequent to the signing of the Armistice, shipbuilding operations were discontinued at Chickasaw and in due course a substantial portion of the shipbuilding plant was dismantled and all but approximately 400 of the original 1200 houses were sold and removed from the village. The remaining users of water therefore consisted principally of the 400 houses in the village, the electric power station and a few minor units in the plant area.

In 1928 the Alabama Water Service Company obtained a franchise to operate a water supply system in the City of Prichard, Alabama, a community about two miles from Chickasaw, and in a considerable territory contiguous thereto. Studies were made by the Water Company of wells as a source of supply for the new system and the Company also negotiated with the Chickasaw Utilities Company for purchase or lease of its water works facilities. As a result of these negotiations the Chickasaw plant was leased by the Alabama Water Service Company. It was decided to install a million-gallon filtration plant which included equipment to afford full treatment for color removal, clarification, and disinfection.

The interested Companies, in coöperation with the State Board of Health, undertook experiments to determine the best method to provide full treatment (including color removal) at this plant. The first experimental work was done in February and April 1928 and consisted of both jar experiments and an experimental filter. Chemicals used in these experiments were alum, ferrous sulphate, lime and soda ash in various quantities and combinations. It was the opinion of the investigators that the best results of coagulation and color removal were obtained when 3 grains per gallon of lime and 5½ grains per gallon of alum were used. The raw water showed an alkalinity of 2 parts per million, color 22, turbidity 3, and pH 6.0. The filtered water had an alkalinity of 8, color 0, turbidity 0, and pH 6.4. It was concluded on the basis of these findings that a treatment plant could be operated satisfactorily and at a reasonable cost. Plans were prepared in accordance with recommendations

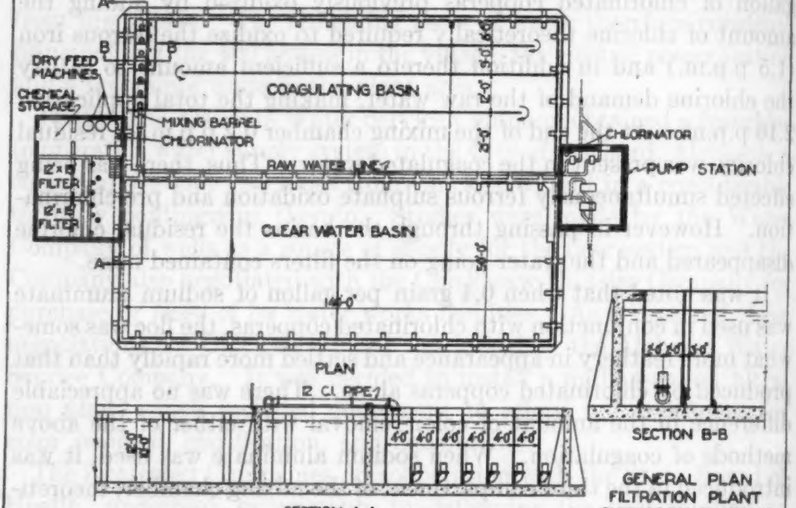
made as a result of the above experiments, and construction work on the plant was begun the first week in January, 1929.

Subsequent to commencing work on construction, L. H. Enslow suggested the possibility of using chlorinated copperas as a coagulant. It was pointed out that, if this treatment were used, no change in the plans of the new filtration plant except minor changes in chemical equipment would be necessary. Laboratory scale experiments and subsequently plant scale demonstrations were made early in April, 1929. These demonstrations gave excellent color removal. At that time the best results were secured by employing 0.7 grains per gallon of chlorinated copperas previously oxidized by adding the amount of chlorine theoretically required to oxidize the ferrous iron (1.5 p.p.m.) and in addition thereto a sufficient amount to satisfy the chlorine demand of the raw water, making the total application 2.16 p.p.m. At the end of the mixing chamber 0.2 p.p.m. of residual chlorine was present in the coagulated water. Thus, there was being effected simultaneously ferrous sulphate oxidation and pre-chlorination. However in passing through the basins the residual chlorine disappeared and the water going on the filters contained none.

It was noted that when 0.4 grain per gallon of sodium aluminate was used in conjunction with chlorinated copperas, the floc was somewhat more feathery in appearance and settled more rapidly than that produced by chlorinated copperas alone. There was no appreciable difference in the amount of color removal with either of the above methods of coagulation. When sodium aluminate was used, it was introduced in the third compartment of the mixing chamber, theoretically 3½ minutes after the introduction of the chlorinated copperas. Coagulation was readily obtained with various dosages of chlorinated copperas, or with chlorinated copperas and sodium aluminate. However, the color removal was the factor in determining the minimum dosage and, although coagulation could be obtained with smaller dosage, color removal was not complete except with the amount stated.

In designing the new plant, one unit of the storage and settling reservoir was utilized as the coagulating basin and the other unit was used as the clear water basin. A mixing chamber, consisting of a series of seven vertical compartments, 4 ft. square and 10 ft. in depth was used. The raw water was introduced over the top of the first compartment and flowed downward through this compartment, leaving at the bottom through a 12-inch, 90° bend, and a nipple 18

in. long, and working upward through the second compartment. The water passed through each succeeding compartment in the same manner. Arrangements were made so that the water could leave the mixing chamber from any of the compartments, commencing with the fourth. This provided flexibility in operation and allowed the mixing period to be varied according to the water being treated. The water from the mixing chamber entered a stilling chamber, from which it flowed into the first bay of the coagulating basin. The coagulating basin was divided into four bays by three round-the-end



This general plan shows the coagulating basin and clear water basin prior to the construction of the lime mixing chamber in 1937

baffles of wood construction. The baffles were so set that the theoretical velocities decreased from 1.165 ft. per min. in the first bay to 0.445 ft. per min. in the fourth bay.

Water was taken from the last bay by a 700 gallon per minute, 750 r.p.m., centrifugal pump. The pumping of the coagulated water was made necessary in order that a portion of the original storage and settling basin might be used as the coagulating basin. It is interesting in this connection to note that throughout the nearly nine years of operation of this plant practically no difficulty has been experienced in maintaining a good floc on top of the filters.

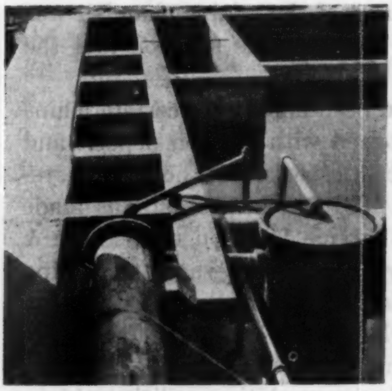
The chemical equipment consisted of three dry feed machines and one vacuum type chlorinator. A fifty gallon barrel placed immediately adjacent to the first compartment of the mixing chamber was utilized as a reaction chamber for the copperas solution and the chlorine.

During 1936 and early 1937, it had been noted that certain mains and service lines were becoming clogged with an iron deposit and considerable difficulty was experienced, especially in hot water systems, with "red water." In April 1937, an inspection was made by A. E. Griffin of the Technical Service Division of Wallace & Tiernan Company and G. R. Kavanagh of the same Company, along with representatives of the Alabama Water Service Company and the Tennessee Coal, Iron and Railroad Company. The principal purposes of this inspection were to determine:

1. Whether the existing method of coagulation utilizing chlorinated copperas and lime was the proper one.
2. Whether the existing method of coagulation was responsible for the incrustation in the distribution system and service lines.
3. What were the proper methods to bring the plant up to full efficiency and to minimize the epidemic of "red water."

The original studies had shown that chlorinated copperas when applied in proper amounts removes the dissolved color at low pH values so thoroughly that it will not return upon the application of lime. On the other hand it was demonstrated that color could be removed by the use of alum, but that when sufficient lime was added for pH correction and corrosion control the color returned. It had been noted that, when lime was added to the filtered water for pH control, varying effects resulted. For instance, on one day lime was added to the clear well in amounts sufficient to bring the pH up to 8.0 without in any way impairing the appearance of the water. On the next day, however, the same amount of lime made the water dull and the lime was cut off. Such methods of operation resulted in fluctuating pH values which nullified in a single day all the good that had been done the day before.

Lime is added at the Chickasaw plant to combine with the dissolved iron left after the formation of the iron-color complex. Thus the floc appearing on the top of the filters should consist of organic iron-color complex and ferric hydroxide with very little, if any, iron in solution. Due to the reduced state of the iron at the point of liming,



Primary mixing chamber and stilling compartment showing terracotta reaction chamber and raw water delivery line

Grid on the discharge side of the stilling compartment of the lime mixing chamber

Lime mixing chamber constructed in 1937 in end of coagulation basin

to the ineffective mixing at the point of liming, and to the fluctuating dose of lime together with an insufficient amount of lime, all of the dissolved iron did not respond to this treatment. This is shown by a sample collected on top of the filters, in which the suspended iron content was 1.10 p.p.m. and the dissolved iron content was 0.60 p.p.m. Had the correct reactions taken place there would have been little or no dissolved iron at this point.

An undue burden is thrown upon the filters by the method of operation described above but even with this burden the filters were doing an excellent job of iron removal. This efficiency was attributed to the coating of iron on the sand grains, which coating acted as a catalyst and very completely removed the dissolved iron.

During this inspection by Mr. Griffin, an abundant growth of what appeared to be algae was noted on the walls and wooden baffles of the coagulating basin. Subsequent microscopic examination of this material proved it to be largely iron bacteria. These growths were not present in the mixing chamber where excess chlorine existed.

The tendency of large numbers of bacteria is to reduce iron to a ferrous state; and ferrous iron is a poor flocculant at low pH. It thus appears that the tendency at Chickasaw had been for the iron which starts off as ferric sulphate and ferric chloride to reduce slowly. By the time the lime was applied, this reduction had reached the point where a pH of 10.0 or better would be required to bring it back to the proper state. However, this could not be done because the removal of color had not been complete due to both inaccurate doses and to reduction. It was quite obvious that, with residual chlorine carried through the basins, reduction would be inhibited, full use of the iron would be made, slime as manifested in iron bacteria growths would disappear and the entire operation of the plant greatly improved. The result then would be a brilliant delivered water which would not be affected adversely by the addition of lime for corrosion control.

There had been a suspicion that the build-up of iron in the distribution system might be due to the passage of iron through the filtration plant. The investigation, however, developed facts which did not substantiate this belief. Samples showed only 0.10 p.p.m. of iron in the water leaving the plant, whereas the content was increased to 1.20 p.p.m. in Chickasaw village a mile distant. This was a greater amount than was in the water before filtration when only 1.10 p.p.m. was present.

An inspection of pipe removed from the affected area revealed evidences of corrosion similar to that noticed in other places where the water had extremely low alkalinity and low pH. It appeared that the accumulation of iron in the system was due to a combination of corrosion and sedimentation which had taken place prior to the initiation of complete treatment and to a continuation of corrosion following these improvements.

Clear well showing shadow photographed through ten feet of water

It may be noted here that several attempts have been made to clarify and remove color from the water at the Chickasaw plant with alum, sodium aluminate, lime etc., all without success due primarily to the inability of aluminum to react effectively with dissolved color to prevent its reappearance when lime is added in sufficient quantities to make the water non-corrosive.

From the above observations it was concluded that:

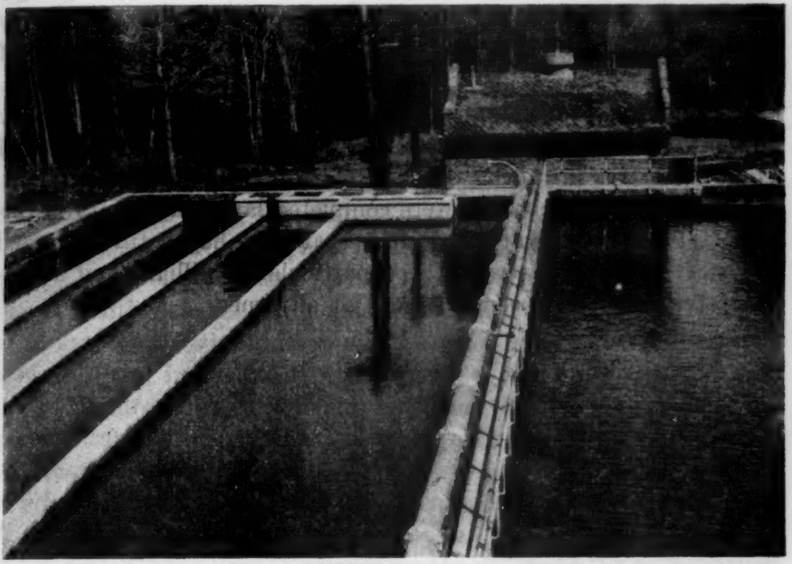
1. Chlorinated copperas is the proper coagulant for the Chickasaw plant.

2. Proper control of coagulation, including the application of the

iron salt and lime, will produce a uniform effluent and minimize corrosion.

3. Maintenance of residual chlorine from the point of the chemical application to the top of the filters will prevent reduction of the iron and greatly improve the operation of the plant.

4. The gradual closure of the pipes constituting the distribution system is not due to passage of iron through the filter but rather to the start of corrosion prior to the erection of the filter plant and inter-



Coagulating basin and clear well with pumping station and lime mixing chamber in background

mittent corrosion following the improvements made in 1928–29. Smoothing out of the treatment will minimize this trouble.

5. The appearance of the water delivered from the Chickasaw plant is excellent. Proper attention to details and adequate provision of the proper apparatus such as stirring machines, mixing tanks, etc. will go far toward the maintenance of this excellence.

As a result of these studies the Engineering Staff of the Alabama Water Service Company, in coöperation with the Alabama State Department of Health, undertook with their approval the structural changes and installation of additional equipment as follows:

1. A secondary mixing chamber, for the introduction of lime as the water passes between the third and fourth bays of the coagulating basin, was constructed. At the same time the original wooden baffles were replaced by new baffles of hollow concrete tile and the primary mixing chamber was reconstructed using the same material. A new reaction chamber was installed. This consisted of a standard 24 × 4-inch terra cotta tee with concrete bottom.

2. A new chlorinator was installed to provide pre-chlorination in the coagulating basin. This machine is a full vacuum type having a capacity of 100 pounds per 24 hours and is equipped with a three-way distributor in order that chlorine may be applied at any or all of three points.

3. New laboratory equipment, consisting of a six jar electrically driven variable speed stirring machine, colorimeter and additional pH equipment, was installed.

All of the above changes were completed late in February of this year. The filtered water has since that time had a turbidity and color of zero, the water has been particularly brilliant and a non-corrosive water has been produced at all times.

CHARGES FOR PRIVATE FIRE PROTECTION

By Reeves Newsom

The insurance men contend, first, that private fire protection is but an extension of public fire protection and that there is no difference between them and further that inasmuch as the cost of fire protection should be paid by the municipality nothing should be charged to the individual who desires private service. This contention brushes aside as a private company's misfortune the fact that almost without exception the amount paid for public fire service does not remotely approach a fair return upon the investment.

Secondly, they take the position that the cost of the service with a reasonable profit added and not the value to the recipient is the proper basis for computing private fire protection charges but this is coupled with a denial of the existence of any elements of cost other than fixed charges and maintenance on the service line in the street and necessary inspection.

In the third place, it is maintained that the fire demand of a city must be taken as a unit, that it depends only upon the size of the city and that the number of outlets available does not add to the capacity demand and should not add to the charges. This contention neglects the fact that in numerous communities the number of outlets is the agreed basis used in computing the charge to the municipality and that, if, instead of a private fire service, it were another public hydrant that was being added, the city would pay an additional charge. This contention further neglects the fact that a sprinkler service line is a different type of outlet from a hydrant located in the public street and represents an added load on the water system after a building is totally afire or walls have fallen and the line is open.

It is further maintained by the insurance interests that private hydrants, standpipes and sprinkler systems rather than exerting in any way an extra capacity demand or cost on the water works above that needed for public fire protection do in fact, by their presence,

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Remarks at the New Orleans convention, April 27, 1938, by Reeves Newsom, Engineer-Consultant, 500 Fifth Ave., New York, N. Y., and President of the A. W. W. A.

reduce the total cost of fire protection and that, as rates for "readiness-to-serve" or demand should be based on cost, there is no basis for including any such element in a charge for private fire protection. Such a contention loses sight of the fact that all fires are not stopped in their incipiency.

Granting that 70 per cent of fires in sprinklered buildings are put out with less than 5 heads, equal to 90 gallons per minute, and that 90 per cent are put out with less than 20 heads or the equivalent of two moderate fire streams, it must be remembered that on the average only about $\frac{1}{2}$ of 1 per cent of the total water pumped goes for extinguishing fires so the amount saved is negligible. Furthermore, when the fire occurs that reaches conflagration proportions the water system must function or a whole section of a city will be consumed.

With flying embers setting fires at innumerable points, with the main conflagration jumping across streets, where the heat is unbearable and with valves covered with water or ice and a mass of abandoned hose there is no chance of shutting off broken sprinkler connections and, running wide open, they put a heavy burden on the distribution system. Also when floods such as have been experienced in the last few years move buildings from their foundations these broken lines add another serious drain upon the rapidly dwindling supply of water in storage. To overlook these as an element of capacity demand is to close one's eyes to the obvious.

Lastly, it is contended that the controlling of a fire in its initial stages is such an important benefit to the neighborhood and community at large that no charge for service should be made to any one willing to install sprinklers and private hydrants at his own expense. This view of the situation neglects the fact that the loss of business due to a bad fire in an individual plant falls heaviest upon the owner of that plant and probably would not be covered by insurance; that the added protection is well worth while to him or he would not be willing to put it in at his own expense; and that, unless the water system can stand the drain of his broken sprinkler line, his installation may be jeopardizing as well as benefiting his neighborhood.

Water works operators, and particularly those connected with private companies, have taken the position that:

1. Private fire service is, and numerous courts and commissions have so held, a specialized service over and above the service that the average taker receives and that the control of the connection is wholly outside of the utility furnishing it or of the public fire protection system.

2. To give special service to certain consumers who make large savings thereby and spread the cost over all the remainder of the inhabitants of the community is discrimination, and that this is true whether the cost is carried by them as taxpayers in the charge for public fire service or as water consumers in the rates for domestic and industrial service.

3. The furnishing of private fire service adds definite and substantial costs not occasioned by rendering any other type of service.

4. Sprinklers are usually installed to care for the hazard which the owner has created and added as a particular load to the general fire fighting requirements and he still requires the protection of the public facilities.

5. The benefits of private fire service accrue primarily to the one receiving them. Such benefits are large and the individual should be called upon to pay for them.

6. If private fire service is furnished without a charge to cover the costs entailed, it will ultimately add more to the charges of the already overburdened water-taker for a type of service not related to his use of water.

There are, in my opinion, some serious weaknesses in these contentions. If attempts were made to charge for other service rendered because it was of special value to the recipient or earned large returns or savings for him, chaos would result in the computation of charges.

It is impossible to maintain that the community at large, including the water company or department, does not receive benefits from the stopping of fires in their incipient stage with the consequent reduction in the interference with business and the preservation of the general welfare.

While it is obvious that added capacity must be provided to render adequate service in a serious fire with broken sprinkler pipes bleeding the system, which results in an increase in investment and costs, it is equally obvious that water companies and departments should prepare themselves to show the make-up of such increased investments and costs.

The charges for private fire service vary through such wide limits that they furnish very little in the way of satisfactory precedent to guide one in a particular case. Charges for 6-inch connections, for example, vary from such nominal amounts as $20 per year up to $500 and sprinkler head charges from 1 cent to 10 cents. It is important therefore that some more definite conclusions be reached to help those who are confronted with this problem.

PRIVATE FIRE SERVICE CHARGES

By John H. Murdoch, Jr.

1. A water utility should receive total revenues equal to the cost to it of rendering its service, including in such cost: operating expenses, maintenance, depreciation, taxes, and a fair return on the property devoted to the service.

2. The total revenue required should be charged against the different classes of customers on the basis of the cost of serving such classes, each class bearing its proper proportion of the total cost and each individual unit or customer bearing the proper proportionate part of the total charged against its class.

3. A correct apportionment of the total cost of service among the several classes and then among the individual customers within each class could only be secured by competent engineers, accountants and operators, uninfluenced by pressure from municipal authorities or selfishly interested groups or individuals.

4. As far as possible, the total cost of all fire service, both general and private, should be secured from the public through taxes and from private fire service customers and should not be borne by the other customers of the utility by increased charges for water for consumption. If the utility receives from the public from taxes the entire cost of all fire service, then private fire service customers should be required to pay merely a nominal charge. Such conditions seldom, if ever, exist. To the extent that public taxes are not used in sufficient amount to meet the entire cost of general or public fire service, private fire service customers should contribute the cost of such service and, in addition, should contribute the cost of private fire service.

5. General fire service should bear that part of the total cost of all

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A discussion submitted by John H. Murdoch, Jr., Chairman, Committee on Private Fire Service Charges, and Attorney, Uniontown Water Co., American Water Works & Electric Co., 50 Broad St., New York, N. Y. This discussion was read at the New Orleans convention, April 27, 1938, by Reeves Newsom, Engineer-Consultant, 500 Fifth Ave., New York, N. Y., and President of the A. W. W. A.

water service which is properly attributable to the general plant and distribution system required to make general public fire service available in all parts of the utility system to the extent required by underwriters' rules.

6. Private fire service should bear that part of the total cost of all water service which is properly attributable to the installation, operation, maintenance, inspection and billing for the individual facilities required for such service, and (second) attributable to that portion of the general plant and distribution system required to meet the potential demand resulting from possible wastage and drainage of the general system through private fire service connections. This apportionment is subject to a probable adjustment or addition under the terms of paragraph 4.

7. Private fire service customers receive a direct individual service and benefit through insurance savings, and they impose an additional burden on the water utility system and should contribute to the bearing of the total cost of water service and fire service.

8. Private fire service installations in general, and private sprinkler installations in particular, are desirable and advantageous to the community in that they reduce the chances of disastrous fires. It should not be overlooked, however, that such installations are not of any advantage to water utilities, except as those water utilities share in general community conditions and advantages. It also must be remembered that no method has yet been found whereby excessive waste and drainage on a general fire service system of a water utility through private fire service connections can be rendered impossible of occurrence during conflagrations, floods, building collapses or other such unexpected happenings. Like possibilities do not apply to public fire hydrants or public fire service systems.

9. Private fire service installations are of most value when installed in properties having an unusual fire risk. Properties which, because of type of construction or contents or use, afford unusual fire risks, add to the general fire risk of the district or community in which they are located. Private fire service installations in such properties reduce the chances of fire and thereby reduce the risk of fire in adjacent properties. The owner of such a high fire risk property benefits the public by such an installation, but he has done little more for the public than remove a public hazard created by his own property.

10. Private fire service connections for sprinkler installations

result in a direct individual benefit to the owner of the property in which the installation is maintained by reducing fire insurance rates and by making service losses less likely.

11. Private fire service installations, especially sprinkler systems, reduce the probability of fire and thereby reduce the probable demand on the fire service system of the utility, but because there is an ever present possibility of excessive drainage of the general fire system through private fire systems running open at full capacity flow, such systems add to rather than subtract from the potential demands on the general system of the water utility.

12. Public authorities are under no obligation to make fire service instantly available in all parts of private property or to meet extraordinary fire hazards created in private properties. The public obligation is met when general fire service is made available to all properties and without special connections for special conditions and entailing special individual advantages.

13. The rates of a water utility may be higher than those which would be condemned by the courts as being confiscatory, and yet at the same time may not be so high as to be unreasonable or extortionate.

14. So long as the net return on property of a water utility does not so far exceed the line of confiscation as to reach the line of extortion, the utility may properly increase its revenues without increasing its costs, and may legitimately accomplish such increase in revenues by the addition of new customers, without a reduction in rates.

15. Because of the general community advantages of sprinkler installations, private fire service charges for such connections should be kept low enough to encourage such installations, if this can be done without imposing a burden on other private customers and without impairing the reasonable earnings of the utility.

LIQUID CHLORINE—A CRITICAL REVIEW OF CHLORINE SPECIFICATIONS AND ACCIDENTS

By L. L. Hedgepeth and W. S. Riggs

One of the most baffling problems connected with serving water works with chlorine is the question of impurities. The customer knows that he has had trouble with the chlorine. After examining the returned chlorine, the plant is certain that the trouble cannot reasonably be ascribed either to the package or its contents. We have found that this paradoxical situation is frequently due to the fundamental difference between truth and fact, in that the plant and customer are in possession of undeniably authentic facts, yet neither has the truth because truth constitutes all of the facts.

This thought may be expanded a bit further by observing that the solution of these queer situations may be approximated only if all available information is at hand. With this thought in mind, we approach this matter of evaluating the quality of chlorine and boiling down the "whys" of its accidents.

Technical literature contains little of a specific nature on chlorine quality stipulations. Since it is an element marketed in a remarkably pure form, any consumer may be certain that 100 lb. commercial chlorine is as near 100 lb. real Cl_2 as his scales can detect. This characteristic of liquid chlorine appears to be one logical explanation of the neglect of this phase by specifications writers.

When the problem, however, is viewed from the "ease of feeding" angle, an entirely different reaction is obtained. Thus, the general "not less than 99.5 per cent pure" quality statement may become absurdly liberal, since it is now known that chlorine containing 0.2 per cent of certain impurities may cause exasperating trouble with a chlorinator.

Efforts to define good chlorine have in the past usually followed

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A paper presented at the New Orleans convention, April 28, 1938, by L. L. Hedgepeth, Mgr., Technical Service Dept., Pennsylvania Salt Mfg. Co., Philadelphia, Pa., and W. S. Riggs, Mgr., Research Laboratories, Pennsylvania Salt Mfg. Co., Philadelphia, Pa.

two courses: (1) the well established refrigerant gases specifications limiting moisture content, and (2) the practical approach based on visual observations. Neither is defensible—neither will serve as a basis for good contract foundations. To illustrate, we quote herewith from purchase specifications with which chlorine companies must conform in order to maintain smooth relations with the trade:

1. ". . .shall be absolutely anhydrous and it shall contain no impurities other than carbon dioxide, oxygen, and nitrogen, which in total shall not exceed 0.3 per cent." Comment: The specification means nothing. Moisture in sufficient quantity to cause chlorinator trouble is an impossibility in steel cylinders. It is not impossible, and means a great deal, in the case of anhydrous ammonia—for which the statement was originally prepared. Likewise, the gases, oxygen, nitrogen, and carbon dioxide, never cause feeding troubles and due to their solubility characteristics are never present in such quantities as to be of diluent significance.

2. The practical approach, such as " . . . shall not deposit a film so as to obscure the visibility of," or " . . . shall not be overloaded to excessive pressure," or "The chlorine shall be pure," or "Defective containers shall be rejected." Comment: The statements are confusing. It is a demonstrated fact that more often than not the wax depositions noted in equipment are the accumulation of solids from many, many cylinders, which accumulation has been dissolved from its point of deposition by condensing chlorine and conveyed to the point of trouble; or the deposition may be due to the over zealous use of lubricants, or to use of improper cleaning agents, or to ruptured pressure gauge diaphragms, or to moisture contamination during shutdown. Why must the chlorine bear the onus of all these troubles? Isn't it better to have chlorine responsible for only its share of the trouble? Specifications of this type place the burden of the trouble on the chlorine in use at the time of the trouble. More often than not, it is found to be of excellent quality and another complaint is then charged to customer idiosyncrasies, or to manufacturer's shortcomings.

The question of condition and type of equipment may, incidentally, be settled by simply saying something to this effect:

"Containers furnished under this contract must conform in every detail of construction, conditioning, appurtenances, loading, and registry with the requirements of the Interstate Commerce Commission for the transportation of liquid chlorine in interstate com-

merce," because the Interstate Commerce Commission and its creatures and associates constitute a very effective police body over shippers of dangerous commodities.

The quality sections, however, are not so simple of solution. A simple dependable analytical method is needed to specify the quality of the material. The test usually used for referee purposes is the evaporation of a quantity (usually one liter) of liquid chlorine in a weighed unstoppered Erlenmeyer flask. This test is subject to gross error for several reasons, principally:

1. No account is taken of the low boiling fractions or of the high vapor pressure of many of the impurities. They boil off or sublime off with the chlorine.
2. It is almost certain that moisture will collect on the inside of the flask and thus introduce gross error.
3. A sample of sufficient size cannot be taken for analysis, since the error introduced, through weighing a relatively heavy vessel as compared with the light impurities, is so great as to make the results meaningless.

This method is so unreliable that it will not give even approximate results. Evaluation of liquid chlorine by this method usually resolves into a "good," "fair," or "bad" verdict based principally on visual examination of the residue. In our opinion this is worthless in answering the most important question on a complaint, i.e., "Has this shipment conformed to the contract?"

GRAVIMETRIC DETERMINATION OF TOTAL ORGANIC IMPURITIES

Recent developments in chlorine evaluation technique have substantially reduced the error in the observation and a workable method is now being employed. This method has yielded most promising results in quality control. Ten liters (about 33 lb.) of liquid chlorine are evaporated under controlled conditions and the residue carefully removed from the apparatus and quantitatively determined in a smaller flask on an analytical balance.

The writers do not believe that it is necessarily the answer to the quality analytical method needed to tighten specifications for it requires expensive apparatus and is expensive to operate. They do believe, however, that it is entirely satisfactory for the purpose intended, namely—quality control in production, and that it is of sufficient value and interest to analytical investigators to warrant including here.

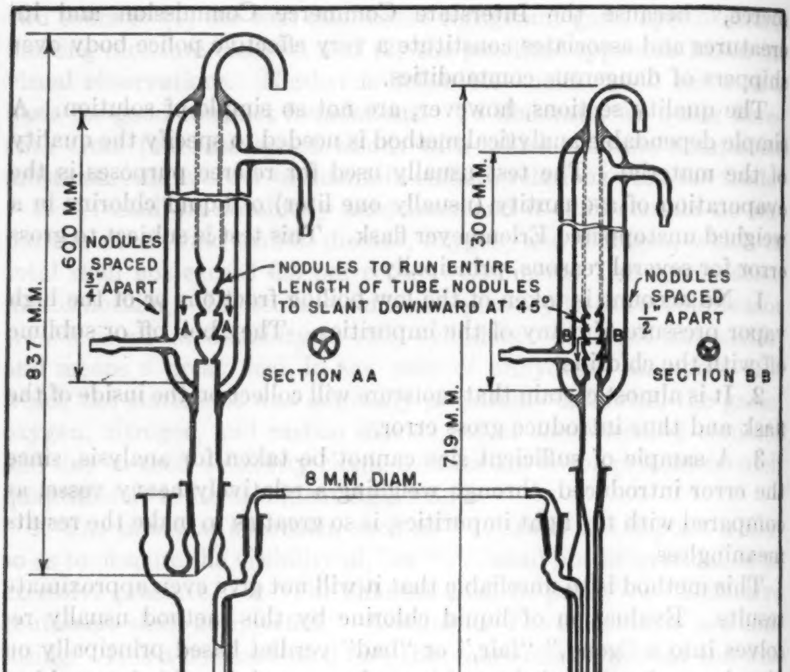

FIGURE 1
SPECIAL APPARATUS FOR CHLORINE ANALYSIS

In considering a more accurate method for determination of organic impurities in liquid chlorine, it is necessary to understand that the principal impurities exert appreciable vapor pressures at ordinary temperatures and, because of this, as well as the tremendous difference in the volume of the chlorine gas and the impurities, it is obvious that some means must be provided to retain them in the apparatus during evolution of chlorine gas therefrom. If this protection is not provided, a substantial portion of them will be mechanically carried out of the impurities determination apparatus along with the escaping chlorine gas. This is exactly how these waxy impurities are carried from the chlorine cylinder and deposited in the delicate parts of the chlorinator.

The apparatus and procedure described herein take into consideration these important factors and, when checked with known quantities of impurities added to 100 per cent chlorine, have consistently checked impurities within ±5 per cent error. Conservative consideration would indicate that the method will indicate impurities within ±10 per cent error under usual analytical conditions.

METHOD

The impurities from ten liters of liquid chlorine are collected in the base of a 12-liter flask by evaporation of the chlorine content at atmospheric pressure (−34.6°C. at 760 mm.). Retention of the impurities in the apparatus is obtained by having the escaping chlorine pass out of the apparatus through a reflux condenser, which is refrigerated with brine from evaporating solid carbon dioxide (−78.5°C.). When the volume of the evaporating liquid has been reduced to 400 ml. or less, it is carefully transferred to a smaller weighed flask and evaporation through a reflux condenser continued until all of the chlorine has been withdrawn. The quantity of the impurities is obtained by weighing the flask and subtracting therefrom the weight of the flask when clean.

APPARATUS

Special design, depicted in fig. 1, consists of:
1 special 12 liter evaporation flask.
1 special 500 ml. evaporation flask.
1 special reflux condenser for the 12 liter flask.
1 special reflux condenser for the 500 ml. flask.
1 special connecting tube for the 12 liter and 500 ml. flasks.

Also needed is an apparatus for cooling the brine, (ethyl alcohol), needed for cooling the reflux condensers to −73.5°C. with evaporating solid carbon dioxide (−78.5°C.) and a brine circulating pump.

Assemble the large flask in place, connect with the condenser, and close the transfer tube with a ground glass plug. Refrigerate the condenser and then place in the flask 10 liters of liquid chlorine. Close the filling opening with a ground glass plug and allow the chlorine to evaporate. About twelve hours will be required for this evaporation. Gentle heating may be necessary with an electric heater placed some distance from the flask.

After the liquid volume in the flask has been reduced to 400 ml., or less, refrigerate the condenser of the 500 ml. flask and transfer the remaining liquid to the 500 ml. flask by means of the transfer tube provided for that purpose. (It will be necessary to close the discharge opening in the 12 liter condenser with a rubber stopper.) Wash the bottom and sides of the 12 liter flask with an additional 50–100 ml. of fresh liquid chlorine. Transfer this wash liquid to the 500 ml. flask as before.

Evaporate the remaining chlorine in the 500 ml. flask and then remove this 500 ml. apparatus to a normally warm room and allow it to come to room temperature. Remove the condenser and close the flask with a ground glass plug. Wipe it carefully with a moist cloth and place on the analytical balance, using a similar flask as a counterpoise. Weigh after 15 minutes. It is necessary to subtract the chlorine gas remaining in the 500 ml. flask from this weight. This chlorine weight may be calculated from the internal volume of the flask, the atmospheric pressure and the temperature at the time the flask was closed.

$$\text{Per cent of impurities} = \frac{\text{Wt. flask} + \text{residue} - (\text{wt. chlorine gas in flask} + \text{original wt. flask})}{\text{Wt. liquid chlorine placed in apparatus}} \times 100$$

NATURE OF IMPURITIES

In our work in this connection, we have found that ferric chloride, hexachloroethane, carbon tetrachloride, and chloroform comprise the bulk of the usual mass found.

These originate during contact between the chlorine and materials necessary for use in its preparation, which include packing, lubricants, resinous sealing compounds for cells and joints, and the binder for the dense graphite anodes.

The total quantity of impurities is nearly always less than the sensitivity of the scales used to weigh the shipping container and, therefore, has no significance from a diluent or inert material standpoint. A few years ago these impurities were present in liquid chlorine of the order of 0.2 per cent by weight. However, by new purification processes, these impurities can be limited to not more than 0.01 per cent by weight as determined by the method outlined above. This concentration of impurities has been found quite satisfactory for use in chlorinators.

Using this method a typical analysis of potential trouble making chlorine will be:

	Liquid Chlorine—% by Weight
Total Impurities	0.1748
Br	0.0096
$CHCl_3$	0.0668
$CHCl_3$ Soluble*	0.0326

whereas, a typical analysis of good water works chlorine will be:

	Liquid Chlorine—% by Weight
Total Impurities	0.0109
Br	0.0031
$CHCl_3$	Nil

These figures may be checked within ±5 per cent on chlorine from the same cylinder. We have also concluded from field observations that the first chlorine may be used with fair success in a chlorinator, but that a slow deposition of the "taffy" will take place at the points of gas expansion (pressure reduction). The second chlorine appears at this time to be quite satisfactory for chlorinator use.

It is believed further that the procedure offers a positive method of quality evaluation and that it will be of interest to the larger water works control laboratories. It will not be practical for use by smaller water works, because the expense involved (the dry ice alone may be as high as $15 per determination) is out of proportion to the commodity cost.

ACCIDENT PREVENTION

The second part of this discussion, approached with some misgivings, relates to chlorine accidents on which information is avail-

* Usually hexachlorethane.

able. Conclusions are a bit dangerous because a severe leak destroys much of the badly needed mechanical evidence. Also, methods of preventing recurrences in one case are not necessarily applicable to similar cases. For instance, throwing a cylinder into water is an excellent disposal measure if the water is less than 49.2°F. but a very poor action if the water is warmer than this temperature, for chlorine is sparingly soluble and slowly soluble in water too warm to form chlorine hydrate.

It becomes difficult, therefore, to write "know how" into accident prevention discussions. Perhaps a digest of all reported water works chlorine accidents for 1935 and 1936, and all of one manufacturer for 1937, may be of more value than theoretical moralizing.

Case 1. Cylinder Accident. Wall of cylinder in service failed. Operators were not provided with gas masks. Nearby industrial company sent men with all-service gas masks. Persons attempting to use them were all gassed—none severely. The all-service gas masks were later found to be in poor condition.

Prevention Comment. 1. Cylinder had passed required five year inspection for strength. Internal examination would have revealed defects not registered during required pressure test. 2. A poor gas mask is worse than no gas mask.

Case 2. Cylinder Accident. Cylinder had been in service for two years in this small water plant. It developed a tight valve during the 23rd month of its continuous use. A tight valve complaint was made to the shipper. The shipper's employee, upon noticing that the leak did not increase when the auxiliary valve was wide open, assumed that the cylinder valve had "frozen" in a nearly closed position. He failed to check the auxiliary valve which, incidentally was plugged. He removed the auxiliary valve and found to his dismay that the cylinder valve had frozen in an open position. He endeavored to cap it, unsuccessfully. He threw it in a shallow warm stream. He pulled several other "iron man" stunts, finally was overcome and was sent to the local hospital. He recovered and was sent home in three hours. Firemen, with all-service gas masks in good condition, recovered the cylinder and capped it.

Prevention Comment. The cylinder had been in service too long for the valve packing to remain resilient. The stem of such a valve should be opened wide and closed tightly at least once daily. Six months of continuous service is all that the average customer may reasonably expect of a cylinder valve. The shippers employee used

poor judgment in that he did not completely investigate his problem before removing the auxiliary valve and he used very poor judgment in not having his gas mask available when he removed the valve.

Case 3. Cylinder Accident. Cylinder developed a tight valve in service. Attendant on duty disconnected it from line thinking that the cylinder valve was closed. It was not closed and substantial quantities of chlorine were released into the building. The attendant donned a gas mask and attempted to remove the cylinder from the building. The mask was improperly adjusted to the contour of his face and he received a severe dose of chlorine. His superior donned the gas mask correctly and removed the cylinder from the building. He capped the valve against pressure and thus stopped the escape of chlorine. Shippers employees arriving later at the scene, closed the valve after loosening the packing. Attendant was taken to hospital and held four hours for observation and sent home for recovery. He lost two days from work. Three other employees were slightly gassed.

Prevention Comment. This is a clear case of negligence. The employee could have closed the valve by first loosening the packing nut. He could have avoided injury to himself and others by knowing how to use a gas mask. He could have avoided injury by being certain that the valve was closed before disconnecting the cylinder.

Case 4. Cylinder Accident. Customer didn't want to buy a chlorinator. He attempted to chlorinate his supply by discharging gaseous chlorine from a 100-pound cylinder through a rubber tube into an open barrel through which cold water was continuously running to the plant discharge line. An official reporting trouble, said in part "...we tried to open the (cylinder) valve a trifle and opened it too much. We (later) tried to close the valve and found it frozen. We filled the reservoir with gas and almost killed a man or two. We finally managed to unscrew the hose and put a cap on the valve outlet." Subsequent investigation indicated that no one was seriously injured.

Prevention Comment. None needed.

Case 5. Two cylinders taken from storage, alleged to be leaking, were thrown into the intake pond. The warm water (August) did did not absorb the chlorine and the valves were rapidly disintegrated under water. Chlorine gushed up into the air and damaged 61 trees adjacent to the pond. No personal injuries.

Prevention Comment. Cylinder should never be submerged in ponds or other bodies of water if the water is warmer than 49.2°F. The chlorine leak will become worse very rapidly and the cylinder will quickly get out of control and do much damage to the adjacent premises. A sure way in all cases is to blow the chlorine into a lime slurry or caustic soda solution. 1.25 lb. caustic soda or lime will be needed for each pound of chlorine to be absorbed.

Case 6. When operator attempted to change cylinders he was gassed because the valve on the cylinder being disconnected was not closed, but was "frozen" open. The operator spent one day in the hospital recuperating from his negligence. Complete recovery was made.

Prevention Comment. It is obvious that one must be certain that cylinder valves are tightly closed before disconnecting them.

It seems reasonable to conclude that the average chlorine gassing accident is due to human error or lack of information. Serious accidents are rare because chlorine serves as its own warning due to its unpleasantness at concentrations far below the danger point. This safety factor should be understood and utilized. These concentrations in air have been mathematically fixed by the U. S. Bureau of Mines to be:

Least detectable odor	3.5 p.p.m.
Least to cause throat irritation	15.1 "
Least to cause coughing	30.2 "
Dangerous for 30 minutes exposure	40–60 "
Rapidly fatal for short exposure	1000 "

Thus one can usually tell when chlorine is escaping before it has reached dangerous concentrations. A gas mask approved by the U. S. Bureau of Mines and known to be in good condition should be donned before the operator returns to make the necessary adjustments.

The CO_2-oxygen mixture method of first aid in chlorine gassing cases is the most important development of chlorine first aid in the past two years. Those of you familiar with fire department rescue work will appreciate that the method is effective because of the fact that the CO_2 concentration of air in the lungs is the breathing control mechanism. By providing an abnormal concentration of CO_2 in the lungs, this method compels the patient to breathe deeply, which takes place involuntarily. The concentration of oxygen in the mixture, being much greater than that of air, more than compen-

sates for the abnormal concentration of CO_2 in the lungs. Since the patient involuntarily breathes deeply of an ample supply of oxygen, recovery is rapid. Results are astounding.

A practical method of making this excellent first aid available to small plant operators, who are not necessarily skilled in the art of handling medical equipment, is to call this method to the attention of the fire department in the locality. This should be of greater interest to firemen than to plant operators, since it works equally well on many other gassing cases needing first aid. The fire department rescue squads of well operated units are adding these small cylinders of 93 per cent oxygen and 7 per cent CO_2, with inhalator to their emergency kits. This appears to be a very good way for operators to make such first aid available for themselves, by persons skilled in the art of administering the mixture.

Discussion by HARRY A. FABER.* Manufacturers should recognize the fact that their efforts to produce a suitable and trouble-free product are well repaid by the pleasant relationship which is established with the consumer of that product. The characteristics of chlorine make it one of the most peculiar of all chemicals employed by water works operators. Liquid chlorine must be shipped, stored, and handled under pressure in steel containers. Thus it remains a more or less intangible material, the feeding and effects of which must be determined by indirect measurement.

While it has been indicated that the chlorine purchased for water works use has been highly purified, the paper also notes that minute amounts of impurities—which would be considered insignificant impurities in other water works chemicals—may be highly objectionable because they affect the feeding of the chlorine. Hitherto, there has been available no dependable analytical method which might be employed to indicate the presence of these objectionable impurities.

While the method which has been presented is reported to prove applicable in manufacturing process control, it is not clear that, in its present form, it may be suitable for inclusion in purchase specifications. Certainly it is new, simple in principle, and a forthright approach to the problem. Several desirable refinements of the method might be indicated:

1. The composition of the residue obtained in the reflux condenser

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should be differentiated on the basis of the objectionable or harmless matter of which it is composed. It is obvious that the bromine, chloroform, and carbon tetrachloride fractions of this residue are of no significance to the purchaser either from diluent or feeding characteristics. But the solid chlorinated hydrocarbons and metallic chlorides are of real significance. It is conceivable that the method of analysis as outlined might be used to condemn a liquid chlorine having a content of impurities which were not objectionable.

2. This method will be noted as lacking general applicability due to the special equipment and expense of operation. Some means of reducing the quantity of dry ice required to refrigerate the reflux condenser cooling brine might be provided. The effective insulation of the apparatus should be one feasible approach to this problem.

3. If this presented method of analysis is to become recognized and used more generally, the exact details of procedure should be available. This is because a large quantity of liquid chlorine is required for a significant sample and very careful handling will be required to insure personal safety of the analyst.

Much comment could be devoted to the accident prevention ideas presented in the paper and two points are especially worthy of emphasis.

1. Although the cases reported which involve any injury to human beings and substantial effect on property are all of those which are available to the authors for the period considered, it does not necessarily follow that this is a complete list. Its statistical value must, therefore, be discounted. A concrete and valuable contribution to the subject of accidents would result if knowledge of all accidents of of such serious nature were available. It is most difficult to obtain reports on accidents which disclose all useful and pertinent information. It might be recommended that the purpose of understanding and preventing accidents would be furthered if all accidents which do occur were reported to the A. W. W. A. sub-committee on hazards, of which Marsden Smith is Chairman.

2. Those accidents which are reported obviously substantiate the authors' conclusions that human error and ignorance are the principal factors in chlorine accidents. In only one of the six cases reported was the accident due to serious failure of the chlorine cylinder. Chlorine is an irritant rather than a poison and the presence of a very small leak is readily apparent to the operator. Such a leak

should be cared for at once and prevented from becoming more serious.

The Chlorine Institute has attempted to advance the safety of chlorine handling through obtaining the coöperation of chlorine manufacturers in matters pertaining to standardization of safety devices and shipping regulations. The Chlorine Institute standard chlorine valve represents an example of progress in this direction. At present work is under way to develop, for the chlorine manufacturers, an approved wall placard which may be distributed to supply dependable information to consumers on matters of safe handling and first aid.

The paper just presented suggests a method of absorbing leaking chlorine in caustic soda slurry (1.25 lb. NaOH to 1 lb. Cl_2). This is a sensible procedure and is probably the safest method which has so far been developed. The availability of approved type gas masks, with operators educated in their use, is a provision the importance of which should be more widely recognized.

It might be mentioned that larger consumers of chlorine have made or are making definite provision to handle possible leaks. Some of these methods are: vaults, to seal and evacuate containers; caustic soda for immersion or flooding of containers; ventilation, with facilities for adsorption of the chlorine so removed. Serious study is being devoted to this phase of chlorine handling and it is hoped that many other suggestions will be forthcoming.

CAN PURCHASED ELECTRIC POWER OR DIESEL POWER BE MADE AS RELIABLE AS STEAM POWER FOR PUMPING STATIONS?

A Round Table Discussion

ELECTRIC POWER

By W. V. Weir

Not many years ago the subject for a discussion of electric power for water works stations would have been "Can Purchased Electric Power Be Considered for Pumping Stations."

In the past several years we have seen many electric-powered pumping stations constructed. These installations are evidence that purchased power has shown a degree of reliability which gives it a very definite place in the water works field. We are now considering whether purchased electric power can be made as reliable as steam power for pumping stations.

Obviously the question of the reliability of electric power cannot be answered categorically. Reliability is a difficult thing to discuss since it is a relative term. For one water works system, electric power may be considered reliable, while for another it may not be so considered. For a number of plants, the answer today is "not reliable," but in a few years more, due to changes in these water works systems, the answer may be "reliable."

The reliability of a pumping station may be considered satisfactory when provisions are made for an uninterrupted, adequate supply of water to all consumers. When a pumping station can operate on purchased electricity and meet this criterion, both the station and the power supply may be considered reliable.

A discussion by W. V. Weir, Supt., St. Louis County Water Co., University City, Mo.; R. H. McDonnell, Cons. Eng., 107 W. Linwood Blvd., Kansas City, Mo.; H. Clay Henning, Eng. in Charge, Operating Section, St. Louis Water Div., 1640 S. Kingshighway Blvd., St. Louis, Mo.; and W. W. Hurlbut, Eng. of Water Works, Dept. of Water & Power, Box 240, Arcade Annex, Los Angeles, Calif. With the exception of the paper by Mr. Henning, which is a later contribution, this discussion was presented at the New Orleans convention, April 25, 1938.

In St. Louis County, Missouri, we placed our old steam plant in standby service seven years ago, and since that time have been operating with purchased power. During this period, if the above criterion of reliability is acceptable, our plant has been entirely reliable. Yet we have had nineteen unexpected power outages in this time. Four outages were for one minute or less; five outages were two minutes long; two were three minutes long; three were five minutes long; the other outages were of seven, eight, ten, sixteen and twenty-six minutes duration. The greatest number of outages in any year was four. The least number was in 1935, when no outages were experienced.

Because of some unusual features of our system, it was even unnecessary to start our standby equipment during these outages. At the highest point in our distribution system, we have a large reservoir from which we pump during periods when the water demand is above the average demand. These pumps and reservoir have adequate capacity to meet the maximum demand of the system and during each outage handled the load while the main station power was off. Five stand towers and two elevated tanks also supply water during the usually short power outages. It is quite possible that a power interruption might affect the operation of these booster pumps as well as the main station pumps. However, the arrangement of the power feeder circuits is such that they can be segregated in a few minutes time to allow either the reservoir pumps or the main pumps to resume operation. In the meantime the standtowers and tanks will maintain the water supply to the system.

This high elevation reservoir and the elevated storage tanks were not constructed because we were operating with purchased power. They were economically desirable when we were pumping with steam power. The reservoir enabled us to pump at night to make effective use of the pumps and the transmission mains. The elevated storage was necessary because the distribution system was strung out over an area of 160 square miles.

Elevated, finished-water storage has a decided effect upon the degree of reliability we can accord to purchased power. Where no storage exists, even short power outages may be serious. Where adequate elevated storage is installed, and this is a noticeable recent trend, short power outages may be of little or no consequence. Incidentally, the use of electric energy for pumping is resulting in the installation of elevated storage so that the cheaper off-peak power

rates may be utilized in filling this storage at night. The elevated storage is in turn improving the reliability of the pumping plants, as short outages become inconsequential.

In mentioning our plant, it was stated that we are maintaining the old steam plant as standby. This will be continued until the time when we have additional storage reservoir capacity near the present reservoir. When we have this additional reservoir capacity, which is desirable from the standpoint of operating economy, it will no longer be necessary to maintain the steam plant. The reservoir will furnish the standby water necessary to supply the system during any power outage or during the period of time necessary to make major repairs to the two power transmission lines feeding the main plant.

Some situations may exist where purchased power may be considered 100 per cent reliable, but such situations will be the exception rather than the rule. Normally, standby in the form of plant or adequate reservoir capacity should be available where purchased electric power is used. This standby equipment may be the steam plant which is being supplanted by a new electric station, as it was in our case. Gasoline engines or moderate cost diesels may be provided if steam equipment is not available. This latter type of power is available for use in a very short time, should there be an electric power outage.

The standby equipment, however, need not be just added expense. Most power contracts base the cost of power on the highest demand established. Since the peak water demand is of notoriously short duration, occurring on just a few of the hottest days each summer, the electric demand charge can be kept down by the judicious use of the standby plant on these few days.

In considering the reliability of purchased electric power for pumping stations, we must realize that this reliability is dependent upon two major factors, first, the ability of the electric utility to provide a satisfactory flow of power to the pumping station; and second, the ability of the station to operate without breakdown.

The electric utilities, as a whole, have in the past few years greatly increased their ability to furnish a reliable power supply. Many plants are now so inter-connected that even the failure of an entire generating plant may not affect the continuity of the power supply. When serious outages have occurred, they were usually followed by the immediate correction of the cause of the failure. The desire

for uninterrupted service is as strong in the electric industry as it is in the water works industry, and we can expect even better service in the future.

In considering the use of purchased electric power, a careful survey should be made of the service record of the local electric utility and its ability to furnish a satisfactory supply of power. The diversification of generating equipment is important. At least two stations should supply power to the transmission lines. The transmission lines which will serve the pumping plant should be critically inspected. The necessity for an uninterrupted power supply should be made plain to the electric utility. In turn, the utility company should be frank about what it can do, what construction it will undertake, and what degree of constancy of service can be expected.

No difficulty should be encountered in establishing an arrangement whereby the water plant becomes a preferred customer of the utility. Should the power supply be curtailed, the water plant should be one of the last customers to be cut off and one of the first to regain power when the service would be resumed.

Where electric power is now used for pumping water, accurate records should be kept of the frequency and duration of power outages. If they become abnormal in number or length, a complaint which can be based upon facts may bring about the desired improvement in service, just as a few well founded complaints on low water pressure will stir us to action.

When the reliability of purchased electric power is considered, the continuity of electric service is usually thought to be the controlling factor, whereas the equipment provided for the use of the power is equally as important. The numerous recent installations of pumping plants using purchased power certainly reflects the better service now being rendered by the electric utilities. The reliability records of these plants, however, are good usually because of the reliable equipment available and because this equipment was properly installed and maintained.

The reliability of an electric pumping station depends initially upon the ability of the designing engineers. The proper design calls for the services of an expert not ordinarily found in the organizations of even the largest water works systems. He is the electrical engineer, conversant with the latest developments in electrical control and equipment, who is qualified to lay out a system having the greatest possible reliability. He must be able to select the most

reliable equipment and install it so that it will not only normally function properly, but also so that, when failures do occur, there will be no serious consequences.

After a tentative design is reached, a simple line diagram of the electrical layout should be made, beginning with the generating stations and ending with the pump motors. In making this diagram, the geographic location of the various equipment should be entirely disregarded so that the diagram will be as simple as possible. Such a diagram will show visually the locations of bottle necks between the generating stations and the motors—when such bottle necks exist (and they probably will). If the bottle necks cannot be eliminated they must at least be located so that the operators can know where to expect trouble.

A recent tendency is for more and more automatic control in electric pumping plants. Some fair-sized plants have utilized automatic devices to the extent that the human labor involved is merely for periodic inspection and maintenance. If this trend away from simplicity affords more safety and reliability, well and good. But if these systems are made complex just to save on operating labor, they should properly be questioned. It is very easy to design a plant which will function beautifully 99.99 per cent of the time. However, when something goes wrong, the complexity of the station may be beyond the capacity of the operator to do what is necessary to keep the plant operating, or to get it back into operation quickly.

The pump station operator must be kept in mind when the plant is designed. The use of all the latest improvements in electrical control equipment may lower the reliability of the station if the operator is unable to understand and repair this equipment in an emergency. The station may be so designed that the operator is the bottleneck.

When an electric pumping station is completed, its reliability depends upon the care and attention it receives. Electrical equipment has the faculty of working well or not at all. It seldom gives much warning that it is going to fail. For that reason an electrically powered plant requires a different type of maintenance program from that to which we are accustomed in a steam plant. Transformer and switch oil must be tested. Oil levels in transformers and bushings must be watched. Relay settings must be recalibrated with special instruments since an error of a small fraction of a second in the operation of a relay may be serious. Contacts must be kept clean. Motors must be dismantled, cleaned, and painted. Dust,

lint, and cobwebs must be removed. Cleanliness becomes not a virtue but a necessity. A thorough routine maintenance system must be worked out and religiously followed.

Regardless of the competency of the design, the selection of equipment and the careful maintenance of the pumping station, failures will occur. The operators must be furnished with material with which they can make the necessary repairs or replacements. Where it is impractical to install duplicate equipment, spare parts such as relay coils, motor coils, contacts, bushings, insulators, special fuses, etc., should be available. Since it is impossible to foresee all of the trouble which may arise, material for temporary connections should be available, such as cable of proper sizes, clamps, and insulators. The operator may be able to bypass faulty equipment in much less time than he can locate the fault. He will then have time to make the proper repair. No hesitancy should be felt about calling upon the electric utility for advice or assistance, should either be needed. Its organization will be able to render service not obtainable elsewhere.

Can purchased electric power be made as reliable as steam power for pumping stations?

The past few years have brought us much improvement in the continuity of electric service at our substations and on our switch boards. We have a great deal of efficient, sturdily built equipment to select from. Controls and safety devices are available which function with superhuman accuracy. Trained men, who understand electrical equipment are increasing in number. We are finding that our distribution systems need elevated storage supplies and we are constructing them. Instead of tearing down our supplanted steam pumping stations, we are finding them to be excellent standby plants. Internal combustion engines are doing good service as standby units. All things point to increased reliability.

Purchased power has its shortcomings. We should not try to gloss them over, but should build our plants and systems to minimize them. We are in what has been termed an "electrical age." If we are to obtain the economies this new development has for us, we must be watching for ways to make this power more reliable.

Many pumping stations are today operating successfully on purchased electric power. Gaged by all the criteria we have, they are reliable. The consumers are getting an adequate supply of water all of the time, and steam power can offer no more than that.

DIESEL POWER

By R. H. McDonnell

Since the first commercially successful diesel engine was built in this country in 1898, this type of prime mover has been developed at an unusually rapid rate until at the present date it is being given the most serious consideration by nearly every field of activity in which a reliable, economical, and flexible source of power is a vital factor.

In passing, I might add that the diesel engine offered today is indeed a superior product to that offered a decade ago. The depression, with its attendant inactivity in engine production, permitted technical research and development, which has resulted in a simpler, more rugged, more economic, and definitely more reliable engine.

These improvements consist, in the main, of the following:

1. Elimination of four-cycle engines from consideration in installations of over 1,200 hp.
2. Practically universal adoption of the solid fuel injection system.
3. Increased rotative and piston speeds through improved balancing and better metallurgy.
4. Abandonment of crossheads in all but the largest engines.
5. Use of force feed lubrication.
6. Pump or blower type scavenging.
7. Reduction in mass and weight.
8. Increased economy of operation.

With these advantages apparent, the diesel engine is being considered and adopted by an ever-broadening field of users. Since 1933, when 280,000 hp. were produced, the growth of usage has been decidedly marked: in 1934 it was 750,000 hp.; in 1935, 1,250,000 hp.; in 1936, 1,900,000 hp.; and in 1937, 2,850,000 hp. There are installed in the United States today some 11,025,000 hp. of diesel engines. A breakdown of usage of installed horsepower is shown in Table 1.

I feel it is practically obvious that in nearly every usage listed above continuity of service or maximum reliability is a paramount and vital factor.

I think the absence of "aviation" from the list of diesel users in the United States should be mentioned. Unfortunately, this country lags far behind foreign countries in this field. Germany, France, and a number of other nations have developed the aviation diesel

to a high degree of perfection—sufficient, I might add, to permit its regular use in "cross ocean" and extended flights both for airplanes and lighter-than-air crafts. However, I must not digress from the main purpose of this paper, reliability of diesels for water pumping service.

The reports that were available dealing with the reliability of diesels were somewhat general in character and dealt, in the main, with diesels in central station use (both private and municipally-owned), and in a very few instances with engines in water service alone. I was fortunate, however, in finding two documents quite exhaustive in their treatment of diesel reliability.

TABLE 1

Installed Diesel Horsepower in United States

Marine	1,800,000 hp.
Navy and Coast Guard	500,000 hp.
Railroads	300,000 hp.
Buses, Tractors, Trucks, etc.	2,600,000 hp.
General Industry	1,800,000 hp.
Public Utilities	1,000,000 hp.
Ice Plants	200,000 hp.
Petroleum Industry & Pipe Lines	1,000,000 hp.
Municipal Power Plants	800,000 hp.
Water Works	175,000 hp.
Irrigation	200,000 hp.
Quarries and Mines	250,000 hp.
Cotton Gins	200,000 hp.
Government Building	200,000 hp.
	11,025,000 hp.

It should be noted in presenting the following data that the electric energy generated by diesel-driven generators was utilized by motor-driven pumps. For our purpose in considering reliability, I feel that this condition in no way detracts from the basic consideration of my subject.

When one considers the reliability of a type of prime mover, the number and length of outages or interruptions of service, found in existing equipment under conditions comparable to your specific situation, is of primary importance. Therefore, the balance of this discussion is devoted, in the main, to presenting a résumé of pertinent facts dealing with diesel engines in service.

At the outset, let us define enforced shutdown as any stoppage

caused by actual or imminent engine trouble. The duration of enforced shutdown is the time elapsing from the shutdown of the engine to the time at which the engine is again ready for service. This definition is taken from the 1935 Report of the American Society of Mechanical Engineers, and differs materially from the Edison Electric Institute definition.

The figures cited are from an "Analysis of Reports on Oil Engine Power Costs" by M. J. Reed of the Diesel Engine Manufacturers Association. The reports themselves were prepared by the special committee of the A.S.M.E. The reports cover a seven-year period from 1929 to 1935, inclusive, and give figures on the operating records of 1,358 engines.*

Table 16 of Mr. Reed's "Analysis" shows that the 1,358 engines* operated a total of 4,232,821 hours in the seven years reviewed, with a total of 1,118 enforced shutdowns for the whole period. The total hours out of service due to this factor were 34,016, or only eight tenths of one per cent of the total operating hours. However, it appears there was a relatively high average of eight tenths enforced shutdowns per engine.* Closer examination showed that a few of the engines* were so-called black sheep and misbehaved with amazing regularity. In one case five engines* were out of service because of enforced shutdowns 88 times in a single year, another group of five were out 86 times, two for 20 times, and so on. The causes for this were possibly old equipment and, more probably, improper maintenance and operation.

The average hours of enforced shutdown were 25 per engine.* This figure can also be the subject of some leniency, for the reasons quoted immediately above.

It was interesting to find that in the specific group where the engines* operated for the highest number of hours per year, the lowest percentage of enforced shutdown time was evident; it being only three-hundredths of 1 per cent.

Table 17 of the analysis showed that, of the 1,358 engines* studies 91.8 per cent of these engines, or 1,245, had enforced shutdown time of 1 per cent or less of the total operating hours. I feel, however, that the most significant fact disclosed in this specific table was that, of the 1,245 engines* with enforced shutdown time of 1 per cent or

* Engines referred to in this paper, when marked with asterisk, actually indicate "Engine years." The aggregate number of individual engines studied was approximately 450.

less, 1,021 engines* had no enforced shutdown periods at all. This indicates that slightly over 75 per cent of the total engines* studied had a so-called perfect operating record.

However, one must be reasonable and realize that these plants with no reported interruptions probably made no record of trifling five- and ten-minute shutdowns caused by minor misadjustments. Thus, when zero shutdowns are reported it would seem more reasonable to list them in the group with not over 1 per cent enforced shutdown. I wish merely to remind you that this report dealt with diesel engines of all ages, operating under nearly all conditions. Consequently, the splendid record seems doubly impressive.

The next section of my discussion is devoted to the 26 diesel plants which were utilized for power generation for ordinary utility service, as well as for water pumping. This list was taken from the "Report of the Sub-Committee on Oil-Engine Power Cost," Oil and Gas Power Division, A. S. M. E., 1936, H. C. Major, Chairman.

21 SELECTED PLANTS STUDIED

This report, in the main, deals with 166 oil-engine plants having 458 engines totaling 246,665 rated b.hp. But, I chose the records of only the 26 plants utilized for water service as well as general power service. Of this narrowed list, only 21 submitted sufficient data to be useful for our purpose. In practically every case I found multiplicity of units in these plants, there being only two installations of one engine each and these enjoyed auxiliary service from a transmission line.

There were 65 engines installed in the 21 plants, yielding a total net output of electrical energy of 43,106,087 kw. hr. All of the plants operated for the full year of 8,760 hours, and the total engine hours operated were 230,093. There were 48 enforced shutdowns, or an average of 73.8 per cent of one shutdown per engine. It must be mentioned, however, that one plant of the group accounted for 33, and another plant for 8 of the shutdowns.

In spite of the fact that one plant was listed with a rather bad record, the total length of time wherein all engines were not available for service, for the entire list of 21 plants, was only 485 hr. When this period is considered, in light of the total engine hours operated of 230,093, it is extremely small, being only .21 per cent, or approximately one-fifth of 1 per cent. The average length of enforced shutdown per engine was 7.43 hr.

One plant accounted for 222 hr. of the total of 485 hr. of enforced shutdown time; another for 120 hr.; undoubtedly in both cases for rather extensive repairs. Excluding these two plants, the enforced shutdown time for the nineteen remaining plants was in no case more than an infinitesimal fraction of 1 per cent.

Thirteen of the twenty-one plants had no enforced engine shutdown whatsoever. Five plants had only one apiece, one plant had two, and the two remaining plants had thirty three and eight, respectively.

ONE TOTAL INTERRUPTION OF SERVICE

In every case I am referring to enforced engine shutdown and not plant shutdown, for there were no total interruptions of service in any of these plants but one. The exception was a plant that was one of the two "single-unit" stations reviewed. In this instance, there was but one enforced engine shutdown, requiring a total outage of 24 hours out of a total operating hour record of 6,147, or .39 per cent total shutdown. The other "single-unit" plant operated a total of 8,584 hours without a single enforced engine shutdown. Truly a remarkable record.

The two plants utilizing diesels for water service only, had the following records, although both were served by auxiliary power service:

The first plant had two engines with a total installed horsepower of 1,750. It operated only 1,248 hours of the year as a peak load plant. The total engine hours operated were 1,142, with one enforced engine shutdown of 96 hours duration, or 8.50 per cent of the total operated hours. The second plant had one 200 hp. engine which operated as a base load station for a total of 7,300 operated hours with only one enforced shutdown of eight hours duration or .11 per cent of the total operated hours. The special kind of service demanded of these plants reflects itself in the operating statistics.

Unfortunately, I do not have sufficient space to devote to any special phases or items that are closely affiliated with the continuous operation of diesels. But, there is the question of the future supply of fuel which is ever recurring. I do not feel that this subject need concern any of us in our generation or for many more to come. The question of expense or cost of proper maintenance is vital, but properly belongs in other discussions. Trained and efficient personnel is another factor that is of great importance, but here, too, is

more fuel for future discussions. I have dealt, in the main, with the single phase, mechanical breakdown, and hope that the records presented are sufficiently ample and broad to give a fairly accurate picture of diesel engine experience.

With the available records before me, it seems worth while to sum up the facts gleaned from the records covering a total of 1,426 engines* in service over an eight-year period:

1. The average time out of service for each engine* due to enforced shutdown varied in the two main groups, but was well below 1 per cent of the total operating period.

2. Of the 1,426 engines* 1,059 were not out of service a sufficient length of time to report any enforced shutdown whatsoever.

3. There were 247 engines* down less than 1 per cent of the total operating time.

4. There were 38 engines* down between 1 and 2 per cent of the total operating time.

5. There were 32 engines* down between 2 and 5 per cent of the total operating time.

6. There were 50 engines* down over 5 per cent of the total operating time.

This seems a significant record for a prime mover that has been utilized commercially for only a comparatively short time.

We are all aware that the utmost reliability is demanded of any source of energy utilized for water service. This requirement is fixed and unrelenting. I feel that the diesel, upon its merits and records, warrants the most careful consideration for this type of service. Of course, one must always have multiplicity of units to assure 100 per cent continuous operation. This is true of any source, because no man-made machine is free from the possibility of mechanical failure.

I have dealt with the primary question faced in selecting a proper source of energy for water pumping service—that of reliability. The diesel engine has this essential quality to an outstanding degree.

STEAM POWER

By H. Clay Henning

The selection of mechanical pumping equipment is not given the careful consideration it deserves in the compilation of a complete engineering analysis preparatory to the construction of a water works station. The mechanical equipment is the heart of any pumping station. The major part of the operating expense is the cost of running this equipment, regardless of whether the units are equipped with diesel engines, electric motors, or steam engines. The principal reason for this negligence in studying the question in greater detail is, perhaps, that the initial investment in pumping equipment is small, compared to the expenditures for buildings, basins, filter plants, reservoirs and other parts of the completed system.

The pumping units should be selected with the greatest care after a prolonged study. The problem should be considered strictly as an engineering question, with due consideration being given to all local conditions. The initial cost of the various types of units, with the necessary auxiliaries, should be compiled and reduced to a yearly fixed charge based on the prevailing interest rates and the estimated life of the units. To this fixed charge should be added the estimated yearly cost of operating the various types of units. This latter charge is based on the efficiencies, as guaranteed by the builders, converted to oil, kilowatts, or tons of coal required. Local prices will have great weight in these items. Also local conditions will be of vital importance in the labor question for each type of equipment.

A steam driven station is burdened with a larger initial investment, due to the purchase of complete boiler room equipment. However, if the station is located in a section of the country where the price of coal is reasonable, the initial increased expenditure is easily justified, despite the fact that more men are required to operate the plant.

The modern tendency for high speed in electric generating stations is not in accordance with the thoughts of the early water works engineers; neither is it attractive to the pumping stations of today. Back in the early days of the walking beam engines, the speed limit was restricted due to the massiveness of the moving parts. With the introduction of the horizontal compound steam engines and, later on, the vertical triple expansion engines, the speeds were increased very slightly. The main thoughts behind these progressive

steps in the development of the steam engine were economy and reliability. The vertical triple expansion engines and the vertical compounds were built for endurance. Witness the large numbers of these units still in existence and actively engaged today, after twenty-five, thirty and up to forty years of service. It is a difficult problem to estimate the probable life of them. In the St. Louis Water Division are a number of these units, several of them installed forty years ago. Today they are pumping more economically than when they were installed. This improvement in efficiency is due to the use of superheated steam and the wonderful running condition of the units. They show no ill effects of the wear and tear of the years of service and there is no apparent reason why they should not be giving the same satisfactory service for the next forty years. Obsolescence may retire them, but if they continue to get the same attention and care in the future as they have in the past, they will be useful for a number of additional years. Maintenance is not excessive provided they are checked over periodically. Minor adjustments and replacements must not be postponed indefinitely. This would be bad practice for any type of mechanical equipment. If taken in time, the repairs can be made very easily without a large outlay of time and money. If the men actually operating the units are deeply interested in their work, they will detect a defect and quickly remedy it, before serious damage is done. Such is one advantage of slow speed pumping equipment. Under actual running conditions, using superheated steam, these units deliver 200 ft. lb. of work per B.t.u. in the steam consumed.

LET THE OLD BUT ECONOMICAL ENGINES STAND

Water works employees, who have spent a great number of years running the old vertical triple expansion pumping engines, have a great deal of respect for them. There is a considerable sentiment connected with their reliable and economical performance throughout the years. Let them stand there and continue on indefinitely with the economical delivery of water.

Progress is always the watch word of the times, and water works design keeps in step. With mounting costs for buildings came the urgent need for a pumping unit of larger capacity, better adapted to the use of higher pressure steam, that required less floor space, and less housing volume and less initial investment. The answer was the horizontal steam turbine driven centrifugal pump. These units

are more compact, simpler and easier to operate, and lend themselves very readily to water works service. Furthermore they are built for the higher temperature steam conditions of today. Their economical use of steam is steadily improving from year to year. It is common knowledge that larger units of this type are delivering 175 ft. lb. of work per B.t.u. Naturally the turbines have completely supplanted the triples in the newer pumping stations. The picturesqueness of the triple with its innumerable moving parts was a lasting thrill to the spectator. What a contrast now. The only visible moving part on the modern centrifugal pumping unit is the flexible coupling. Now the spectator is thrilled at the immensity of the discharge pipe.

The steam turbine may consist of one or more steam wheels, called rotors. The number and size of the wheels depends on the horsepower required. The multistage turbine, using high pressure steam, is further improved by being divided into two small turbines, one using the high pressure steam, the second, called the low pressure unit, using the exhaust from the first unit. This turbine is known as a compound unit and is used on the larger capacity, high discharge head pumps. Steam turbines for water works service have speeds up to 4,500 r.p.m. The speed is reduced through efficiently designed helical gears. All steam turbines, like their predecessors, are run condensing.

In the progress of steam engine drives for water works pumps, few of us have seen, but most of us have heard of the walking beam engine of years ago, with its massive cast-iron beam, and well-designed bucket type pump, whereby the water was lifted up by the bucket and then pushed into the discharge pipe. These were superseded by the compound engine and later by the triple expansion engine. These units use the plunger type pump. Next we come to the steam turbine driven centrifugal pump. Who knows what the next step may be? It is hard to predict. No doubt the steam turbine will continue to improve in design and efficiency. Perhaps in these days of advanced knowledge in alloy steels and the vast improvements in other metals, combined with better coördinated shop methods and American ingenuity, the good old reliable triple expansion steam engine may come back, in a radical change in design, and be a strong competitor in the field of water works equipment.

GENERAL CONSIDERATIONS

By W. W. Hurlbut

Can purchased power and diesel power be made as reliable for pumping purposes as steam power? Of course, an off-hand answer would be in the affirmative. Reliability, with modern equipment, is somewhat like any other material commodity and can be purchased in almost any quantity required.

Speaking in a more practical vein, a great deal depends on circumstances, but the conditions which might govern in particular instances are numerous and diverse. In fact, they are so numerous and diverse that it seems irrelevant to attempt to consider cases in point. Consequently, it seems best to deal only in generalities.

Returning to the designated subject, the injection of the question of reliability, presupposes the possibility of interruption of pump operation by factors not immediately controllable. Such factors are of two kinds, "Acts of God" and "Acts of Man."

"Acts of God" include earthquakes, storms, floods, wars, and bad politics. "Acts of Man," wrong design, poor construction, and faulty operation.

"Acts of God" are apt to strike almost any place at almost any time, but, like knocks of opportunity, they seldom strike the same place twice in succession and also rarely appear at widely separated points simultaneously. "Acts of Man" are ubiquitous, and are usually due to ignorance, slothfulness, lethargy, and just plain carelessness.

Our purpose in operating a water pumping installation is to impart energy to water in a pipe. Since energy in usable quantities is available only in the potential state in fuels and water existing at high elevations, energy must either be brought into the plant as fuel or as electric power by means of a power transmission line.

In the case of the isolated plant, energy must be brought to the site as fuel, and all apparatus required to transfer the energy from the fuel to the water is concentrated in one installation. Consequently, owing to the before-mentioned tendency of "Acts of God" to strike in relatively small areas, the likelihood that operation will be interrupted by such causes is relatively small.

On the other hand, much more apparatus, and much more complicated apparatus, is required to carry on the transfer of energy than would be required in the plant using purchased power, and for

this reason the chances for "Acts of Man" to interfere with the continuity of operation (speaking very conservatively), are at least correspondingly greater.

In the case of the plant using purchased power, the various pieces of apparatus required to transfer energy from the state in which it exists in Nature to the water in the pipe are spread over more or less geography. Consequently, the chances that some plant will become an innocent bystander in an "Act of God" are relatively much greater. On the other hand, owing to the simplification of the apparatus in the pumping plant itself, the opportunities for human fallibility to exercise a baneful effect are greatly reduced.

Again referring to the happy infrequency of natural phenomena, the mere wide separation, geographically speaking, of the points at which energy is filched from Nature and converted into electrical power makes it very unlikely that two such sources of power will suffer simultaneously from the ravages of nature. Consequently, if electric power is supplied to a pumping installation from two fairly widely separated sources and is brought to the plant over well constructed lines entering the neighborhood of the plant from widely separated points of the compass, the likelihood of interruption of operation from these causes is small indeed. In order for any "Act of God" to cause a cessation of the operation of the plant it would of necessity have to occur in the immediate neighborhood of the plant and could as well affect an isolated plant as one using purchased power.

So it would seem that purchased power, if it is supplied from two or more sources over duplicate lines, is at least as reliable as isolated plant power unless a tremendous duplication of apparatus is to be considered. It would seem that this is true because the required apparatus in the pumping plant is simple and the geographic spread of sources and transmission lines makes a poor target for the forces of Nature; also, that isolated plant power tends to be unreliable because of the greater complication of apparatus installed in the plant necessitating better qualified and more highly paid labor and the exercise of greater vigilance both in operation and in maintenance.

We are still faced with the question of diesel power versus steam power—either one to be generated in an isolated plant. Age-begotten experience makes for reliability in man; and the steam engine, be it reciprocating engine or turbine, is old. The diesel engine is relatively new. Either one may fail at the most inopportune time

and such failure may be subverted only by duplicate apparatus. In this regard, all depends on how much may be spent for reliability. An oiler may fail to notice a hot bearing on a steam engine or turbine. An up-keep man may fail to keep the main bearings on a diesel engine in proper alignment. Either one of these causes may result in a ruined shaft. But the question as to which is the more likely to occur and which would be the most expensive to correct cannot be answered offhand.

The organization with which I am connected uses all three types of power. All have proved to be reliable if the apparatus is properly maintained. Emergencies due to failure of equipment have arisen in the past with apparatus using each of the kinds of power, but such emergencies have been met without serious interruption of service. In one instance a fairly large centrifugal pump was purchased on one day and was in operation before daylight the following morning. In another instance, failure of a fairly large steam pumping engine made it necessary to install a 500 hp., electrically-driven pump including the power service and the unit was in operation in less than forty-eight hours.

Both of the failures cited above were due to "Acts of Man." But we can state that no failure of purchased power has made it necessary for a consumer to go to his place of business unshaved or lacking his morning coffee.

PLUMBING HAZARDS AND THEIR EVALUATION

By Arthur P. Miller

The American Water Works and the New England Water Works Associations have both given much time to the study of cross-connections between potable and non-potable drinking water systems. Conclusions opposed to such connections without adequate protective devices have come from these studies and both corrective and prohibitive steps have been taken by many official agencies.

Not so much thought has been given, however, to the possibility of contaminating the drinking water supply through inter-connections in the plumbing systems within structures. Except for a few isolated cases, water purveyors have considered that their duty was accomplished when pure water was delivered to a building. Attention to the movement and use of the water within a structure was not deemed necessary unless it was for such economic reasons as waste or excessive use. The few who held a different philosophy believed that any action within a building which resulted in a deterioration of water quality was the concern of the purveyor. It is too early to say which school of thought will receive more support but recent events would indicate that those engaged in supplying drinking water should consider carefully the advisability of extending their vigilance to water quality up to the time of its release from the pipes.

The possibility of hazards in plumbing is not a new subject. It has been discussed for a number of years by those closely related to the manufacture and installation of plumbing and plumbing fixtures. It was not until the outbreak of amebic dysentery in Chicago in 1933, however, that Bundesen, Connolly and others focused national attention on the question. Since then there has been much more activity by health and water works officials and scientific and trade organizations. Today these activities include research, investigation and surveys as well as remedial, corrective and preventive measures.

A paper presented at the Four States Section meeting, October 6, 1938, Washington, D. C., by Arthur P. Miller, San Eng., U. S. Public Health Service, New York, N. Y.

Research has pursued different courses among which might be mentioned a study of the prevalence of insanitary and defective plumbing fixtures in use or for sale; the determination of the causes and effects of back-flow and vacuum formations and the frequency of vacuum occurrence; and a consideration of the merits of various plumbing fixtures and protective devices and of the factors necessary to the proper, safe and sanitary design of plumbing fixtures.

Other persons and groups have devoted their time to determining the prevalence of plumbing hazards by carrying through surveys of plumbing and plumbing fixtures. Representative buildings of various types have been studied; particular types of buildings have been selected and thoroughly investigated; and numbers of buildings of all types have been included in surveys.

A third general line of effort in this broad field has involved the preparation of new plumbing codes or the revision of existing ones prohibiting the installation of disapproved fixtures and inter-connections. Typical of the advances being made in this connection are the rules and regulations adopted by the New Hampshire State Board of Health on March 9, 1938 which are most explanatory with respect to the public health hazards in plumbing fixtures and installations.

FACTORS INFLUENCING HAZARDS

Broadly speaking, the conditions which cause a fixture to be hazardous are two in number: (1) The design of the fixture or the way in which it is installed must be such that a direct or indirect path for the spread of contamination exists and (2) the conditions which will cause that direct or indirect path to be operative must be capable of occurring.

The paths through which contamination may spread through a fixture or installation are not very difficult to locate but the conditions which will bring into play these artificially established courses at a susceptible fixture are not so readily demonstrated. These conditions are (1) the occurrence of a vacuum in the supply pipes causing back-flow and (2) the development of a pressure in a fixture, appliance or pipe system to which the water supply is connected greater than that in the supply system itself. Coupled with these two major factors, other minor conditions may be needed to create a definite hazard. These are (1) leaky valves, (2) leaking water, soil and waste lines, (3) the activities or actions of vermin, birds or

small animals in parts of the water systems not under pressure, and (4) dust reaching, water-holding devices.

A list of fixtures which with appropriate physical surroundings might become hazardous to health would be quite long. The development of mechanical devices in which water is used in their operation and the industrial uses to which water is now put have resulted in a large number of different types of plumbing fixtures and appliances; some safe in construction and installation; others not so safe.

Descriptions of some of the simpler and more commonly used fixtures will serve to illustrate the possibilities of hazardous conditions arising

Flush Valves. A very common inter-connection which has been given too little attention in past years involves the simple flush valve on the siphon-jet type fixture.

Satisfactory mechanical operation of most flush valves depends upon the maintenance of a continuous positive pressure in the water supply lines. Should a vacuum occur in the supply line, the flush-valve may open and back-siphon the fixture contents through the siphon-jet opening. It is not necessary for a siphon-jet fixture to be stopped up in order for back-flow to occur. Even should the flush valve not open, a leaking valve would permit contaminating liquid or material to pass through it.

Flush Tanks. To insure quietness of operation the inlets to flush tanks are almost always submerged. If the ball-cock leaks or if it is opened for the purpose of filling the tank during a period of vacuum in the supply line, a portion of the tank contents may be back-siphoned, carrying with it any pollution which may be in the tank.

There are three types of flush tanks in general use for toilets: (1) the tank built integral with the toilet bowl, (2) the low tank, separate from the bowl, the outlet of which is usually two or more inches above the top of the bowl, and (3) the high tank, most often used with a wash-down bowl.

With the integral tank there is so little difference in elevation of water in the tank and bowl that only partial stoppage in the latter will permit a mixture of the bowl and tank water. Such fixtures should, therefore, be considered deficient unless the tank-water inlets are adequately protected against back-flow.

Low tanks are also subject to pollution by a mixture of the bowl contents with the tank water. For example, if a bowl stoppage

occurs and a rubber force-pump is used, a portion of the bowl contents may be injected through the siphon jet openings into the tank. The polluted tank contents are then subject to back-siphonage through the submerged inlet in the tank.

If the cover of an integral or low tank is air tight, or nearly so, it is possible for the bowl contents to be drawn from the bowl through the tank into the water supply lines, if the tank inlet orifices are submerged or unprotected against back-siphonage.

The possibilities of back-siphonage from a high tank to supply lines is quite as great as in the case of the low and integral type tanks. High tanks are usually open and consequently are subject to air pollution but other possibilities of contamination exist, such as by vermin or leakage from pipes passing above the uncovered tanks.

Lavatories, Bathtubs and Laundry-trays. These three fixtures are common to most every home. A large percentage of them is supplied through submerged inlets. Most of these fixtures have an overflow outlet at some distance below the rim but so many conditions may occur to render it useless that it should not be considered as adequate protection against back-siphonage. For example, in almost every installation of this type the overflow is connected into the drain line of the fixture at a point before the trap. Should the drain pipe become plugged beyond this connection it would render both the drain line and the overflow useless as a means of disposing of the water in the fixture. Under such conditions, it is entirely possible to cause the water to rise at least up to the spill line of the fixture, thereby submerging the inlet.

Other Common Plumbing Fixtures. Soda fountain sinks, bidets, aspirators and dental cuspidors present more hazards than most of the fixtures with submerged inlets. As the inlets to soda fountain sinks and bidets are most commonly located at the bottom of the fixture, they are continuously submerged whenever the fixture is in operation.

Aspirators are used to remove fluid contents of tumors and collections of blood during surgical operations and saliva during dental operations; as ejectors in handling fluids in chemical laboratories and waste wash water from wash trays and washing machines in homes. The principle is the same in each case and unless protection against back-siphonage is provided it is possible, when the discharge outlet is submerged, for contamination to reach the water supply.

A very commonly found defect is usually man-made. It is best

illustrated by the sink with an overflow outlet and a faucet above the rim overflow line of the fixture, to which a short length of hose leading to the bottom of the sink has been attached. X-ray photograph and blueprint development trays, and arm and leg baths are variations of the same hook-up. It is a defect almost always found in an autopsy room.

Industrial Equipment. The application and use of water for industrial purposes has created a large number of different types of plumbing fixtures. Among the most common of these appliances

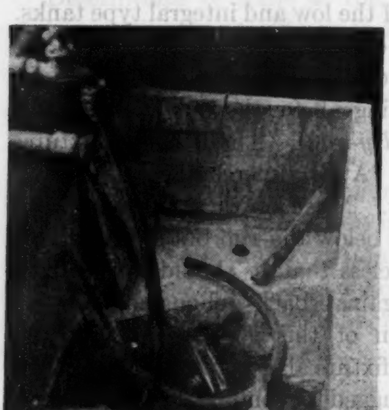

FIGURE 1

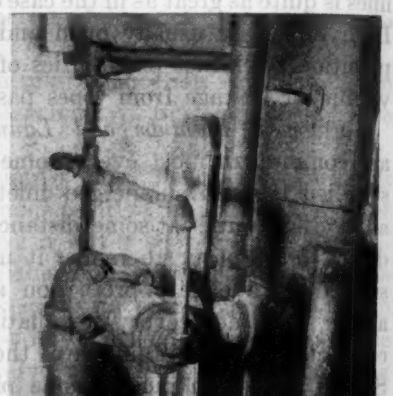

FIGURE 2

FIG. 1. A thoughtlessly made hazard. With a full slop sink, the hose in the present position and a vacuum on the line to this faucet, back-flow could take place.

FIG. 2. On this potato peeler, the waste line (*S*) needs flushing. The water line (*W*) is connected to it for that purpose. The valve separates the wastes from the drinking water if it is tight and never leaks.

are the laundry and dishwashing machines. In most all of these installations, the inlets are either submerged or become submerged when the machine is operated. The occurrence of a vacuum in the supply lines to these fixtures may cause back-siphonage of part of the contents of the devices.

Hospital Fixtures. Bedpan washers and sterilizers may have a portion of their contents drawn into the water supply line when a vacuum exists in the latter, provided the inlet to the fixture is not protected against back-siphonage.

The defects encountered in older hospital sterilizer set-ups are

similar in most all cases. Fortunately, modern hospital equipment has many improvements over the old, although some of the most modern pieces of equipment still have defects due to improper installation or to the design of the fixture itself. Some of the usual defects are discussed briefly here.

1. Improper design of equipment. This may include the omission of a means of draining the gauge glass and the tap of a water sterilizer. If either of these two places contains non-sterile water after the sterilization process, the finished water may become recontaminated through contact with this small quantity of non-sterile water.

2. Improperly designed vacuum-breakers and air-breaks. These may include (a) vacuum breakers with moving parts that are actuated only by the formation of a vacuum in the water line, (b) air-gaps and vacuum-breakers of insufficient size to furnish the air necessary to dissipate the vacuum, and (c) air-breaks and vacuum breakers designed for use on high pressure systems and installed on low pressure lines, and vice versa.

3. Bleeder lines, drains and overflows submerged or directly connected to waste lines. Certain types of sterilizers are equipped with air-breaks on the waste line. The drain line from the sterilizer may be submerged in the funnel or connected into the waste line below the funnel. The same may be true for bleeder or overflow lines. In any case, the purpose of the air-break is defeated if any of the lines are submerged in the funnel or connected to the waste line below it.

4. Direct connection of cooling coil to waste line. The cold water sterilizing unit is equipped with a cooling coil through which cold water passes to cool the water after sterilization. A number of installations have this line connected directly into the waste line without an air break. This is a direct inter-connection between the waste line and the water supply of the building.

5. No bleeder line on filter or inlet valve. The omission of a bleeder line from a filter or from an inlet valve may allow non-sterile water to pass into the sterilizer and contaminate the contents after the sterilizing process has been completed.

6. Improper location of vacuum-breakers and air breaks with respect to the fixture. Insufficient height of the vacuum-breaker above the highest possible water level in the fixture may cause even the best vacuum breaker to become ineffective.

7. Changes in design of the fixture. The use of modern fixtures

and connections is no assurance against defects of installation and operation. Inspections of hospitals have revealed vacuum-breakers and air breaks on the sterilizing equipment which have been taped over to prevent noise and spitting. Proper design should forestall this eventuality.

Miscellaneous. The fixtures so far mentioned are characterized by the fact that the important defect in practically all of them is the possibility of back-flow taking place resulting in the contamination of the water supply. There are only a few fixtures in which contamination and disease may be spread without occurrence of a vacuum. Foremost among these is the drinking fountain. A

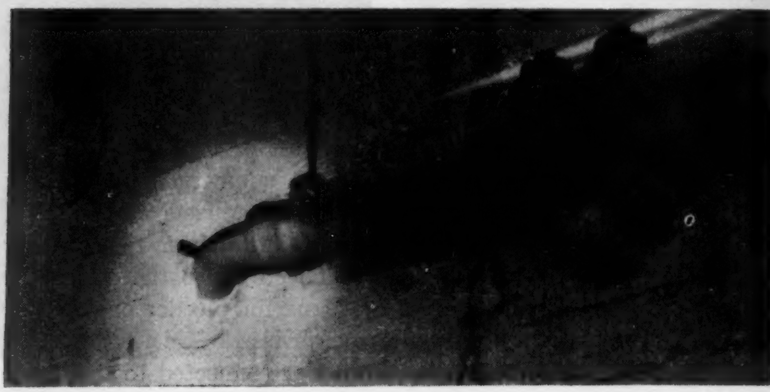

FIG. 3. A wooden plug seals a hole in this drain pipe. Fortunately this line was not over an open top water tank, ice making equipment or food handling or preparation tables.

joint report of the Committee on Plumbing of the American Public Health Association and the Conference of State Sanitary Engineers* outlines the essential factors necessary for the construction of a safe, sanitary drinking fountain.

The use of several types of household filters for the purpose of providing a cleaner supply of drinking water often results in the deterioration of the quality of the delivered water. Unless rigid control is maintained over the cleaning and sterilizing of the filters their use should be discouraged.

Another source of contamination of the drinking water is through

*Committee Report. "Sanitary Drinking Fountains," American Public Health Association. Am. J. Pub. Health, 19: 1223 (Nov., 1929).

the improper location of soil and waste pipes with respect to water storage tanks and food handling and ice manufacturing equipment. The location of a soil or waste pipe over a water storage or supply tank makes possible the spread of contamination by leakage from defective pipes dropping into the tanks. The dropping of any of this contaminating material on food or food handling equipment will have the same effect. In ice manufacturing plants, the improper location of soil and waste pipes above the floor on which the water is frozen may permit leakage to drop into the ice cans and contaminate the ice.

FIG. 4. A 2-inch water line (*W*) is connected to a 6-inch soil line (*S*) to permit the soil line to be flushed. A vacuum in *W* or adequate back pressure in *S* could bring about contamination of the water if the valve shown were open or leaking.

The use of open-top water supply and storage tanks is conducive to the entrance of dust and vermin with a resultant contamination of the water supply.

Another fixture defect that has been brought to the attention of sanitary engineers and health officials recently is the standing waste in bathtubs and lavatories. While the chance for fixtures with this feature to spread contamination and disease is almost insignificant, there remains no justification for its installation and use since the development of a safe and sanitary device of this type is both possible and economically sound.

The survey of plumbing in federal buildings in New York and Detroit made by the Works Progress Administration and the Public

Health Service was designed only to detect conditions that might be hazardous. Consideration was not given to the factors which would convert a faultily designed or installed fixture into a device which could serve as the means of contaminating the drinking water. A fixture in itself may be free of design and installation defects and under no condition could be made to serve as a passageway for contamination; on the other hand, its design or the way in which it is installed may be such that when other factors come into play, it will operate as a channel between a source of pollution and the drinking water.

HAZARD YARDSTICK NEEDED

To secure an accurate estimate of the real hazard surrounding any building's plumbing system, it is essential then that consideration be given to fixtures, the distribution system and pressures. All of these may be involved in any accidental pollution of the drinking water. To know your fixtures is one thing but is there any proof that they will ever function deleteriously with respect to the water supply? That can be proven only by a study of the other two factors. On the other hand, a thorough and complete knowledge of the pressures in a structure is of little use unless it is known that they can affect adversely the drinking water through faultily designed or installed fixtures.

In an effort to rationalize these three variables into some form which might be useful for measuring the degree of hazard to permit comparisons between buildings or between one building and a regulatory standard, Cronkright developed in the office of the author a tentative method of rating.

This method should not be expected to furnish a superlatively exact figure for each building considered, for like most rating schemes, the basic figures depend upon the judgment of an inspecting official. Further, this rating device must be tentative until frequent application either justifies it or indicates valuable and useful modifications. In its application, comparisons should be made between results secured by individuals within the same organization. Only in this way can it be expected that errors of or variations in judgment will be at a minimum. If the results secured by working groups in two or more different cities are to be compared, the procedures of inspection used in those locations should first be standardized. How-

ever, the results from the use of this plan in a group all of whom have been trained together should be in close agreement. Despite these shortcomings, the rating method suggested herewith merits consideration as it furnishes a useful means of comparing the results of several plumbing inspections, an aid which up to now has not been available.

PLUMBING INSPECTION RATING SYSTEM

Building Hazard Rating. Each building inspected shall be given a numerical rating indicative of the hazard presented by all of the plumbing fixtures and installations in place and in use in the building. This rating may be known as building hazard rating. Any increase in the numerical value of the rating shows an increase in the hazard presented.

The building hazard rating may be determined by the following empirical formula:

$$B = KFDP$$

where: B = building hazard rating
K = 1000
F = fixture hazard rating
D = distribution system hazard rating
P = pressure hazard rating

Each of the above three complementary ratings (F, D and P) will depend upon the investigations and conclusions of the organization making the inspections and each will have a definite upper limit. Any rating above any upper limit will cause the entire building to be classed as unsatisfactory. The limiting standards used herein have been established for illustrative purposes only and should not be accepted as applicable to all future work. It is recognized that it will be preferable for each organization conducting work of this kind to establish its own limits to conform to a factor of safety previously decided upon. This would in no way affect this rating scheme except to change the mathematics of the computations.

The constant K in the above formula is set at a value of 1000 only to add significance to the final product. It is an arbitrary figure and has no bearing on the various ratings.

Fixture Hazard Rating. The fixture hazard rating (F) of a building shall be the average of the ratings for each separate fixture and

plumbing installation in the building and may be expressed empirically as:

$$F = \frac{\Sigma(nf)}{\Sigma(n)}$$

where: F = fixture hazard rating
n = number of each type of fixture
f = individual fixture hazard rating

These separate fixture ratings will depend upon the design and the use of each fixture or connection. The numerical value of the rating given each fixture shall be determined by the inspector making the examination in accordance with the limitations shown in table 1.

In connection with the fixture ratings, the existence in a building of one or more separate fixtures or connections having a rating of more than 50 shall be considered sufficient cause to classify the condition of the plumbing in the building as unsatisfactory. Also, a fixture hazard rating (F) for the entire building in excess of 10 shall be sufficient cause to classify the building as unsatisfactory as to plumbing.

TABLE 1

DEGREE OF HAZARD	FIXTURE RATING (f)
None	0
Remote	0–5
Potential	5–10
Definite	10–20
Serious	20–50
The existence and use of the fixture presents a menace so serious as to require correction upon detection	Above 50

In arriving at the numerical ratings to be given to each separate fixture, a siphon jet water closet supplied through an unstable flush valve (a flush valve, the opening of which is facilitated by the occurrence of a vacuum in the supply line to the valve) unprotected by either check valve or siphon breaker would be given a hazard rating (f) of 10. All other fixtures are graded accordingly.

Distribution System Hazard Rating. The distribution system hazard rating (D) defines in figures the condition of the water piping system of a building, the method of operation and maintenance of the distribution system, the type of system in use and the adequacy

of its design. This rating should be made by the official in charge of the investigations and should be based upon his knowledge of the conditions in the building and his observations of the method of operation and maintenance of the distribution system. The numerical value for D may vary between 1 and 5. A value of 1 for a building indicates that the distribution system is free from any defects either in design, condition, maintenance or operation, while a value of 5 shows a distribution system so poorly designed, maintained or operated as to warrant its classification as unsatisfactory.

The small numerical range allowed an inspector in rating the distribution system has the advantage of simplifying the task and, also, of reducing the effects of any errors in judgment on his part in grading the system.

Pressure Hazard Rating. The pressure hazard rating (P) of a building shall express the maximum frequency with which a vacuum may occur in any part of the building. A value of P of 0.001 has been set up as the maximum vacuum frequency permitted without causing the plumbing of the entire building to be classed as unsafe. This figure is obviously an arbitrary one and it should be established only after careful consideration of all related factors by each organization undertaking surveys.

It has been shown by other investigators in this field that the existence of plumbing fixtures and connections of only approved design in a building will preclude any possibility of contamination being spread through the plumbing system. In such a case, the application of this method of rating would indicate a fixture hazard rating (F) of zero. This rating when multiplied by the distribution system hazard rating (D) and the pressure hazard rating (P) will give a building hazard rating (B) of zero which would indicate that the plumbing system of the building was entirely free of any health hazards.

In the distribution system of a building, inadequate design and poor physical condition, operation and maintenance all influence the degree of hazard attached to any defective plumbing fixtures found in a building. The improper location of pipes and plumbing equipment; i.e. the location of soil or waste lines above open drinking water tanks, often presents a considerable amount of danger. The effect of any defects in the distribution system is accounted for in the rating given it by the inspector. In the possible case of a building containing a distributing system of such design, condition,

operation, type and maintenance that it presents no hazard in itself and its influence due to its relation to fixtures is negligible, the distribution system hazard factor D would be 1. This, when multiplied by the other two ratings affecting the building hazard rating, would have no effect on the final product.

The third separate rating, the pressure hazard rating (P), is based on the vacuum frequency in the building. Since the majority of defective fixtures require the occurrenee of a vacuum in the supply line to the fixture before back-flow can take place, the frequency with which that occurs modifies the hazard presented by the fixture. If the vacuum frequency is low, the hazard is low and vice versa. An apparent objection to the pressure hazard rating exists in the case of a building in which the vacuum frequency is extremely low and in which there are one or more fixtures through which contamination may be spread without the necessity for a vacuum to occur. This difficulty can be surmounted only by giving it special consideration. However, the small number of these fixtures as compared with the number of those which do need a vacuum to make them hazardous does not warrant any deviation from the formula devised.

TABLE 2

BUILDING	F	D	P	B
"B"	2.6	5.0	0.25	3100.
"C"	5.3	1.0	0.0000–	0.0000–
"D"	1.8	2.0	0.0024	8.6
"E"	2.7	3.0	0.000051	0.41
"F"	3.3	1.0	0.00015	0.50

APPLICATION OF RATING SCHEDULE

In connection with another investigation, an opportunity became available in New York City to apply this schedule to five office buildings. The results are shown in table 2.

Upon examination of these data, it is apparent that the hazard presented by the plumbing in building "B" is very much greater than that presented by any other building. An examination of the three component parts which make up the building rating (B) shows that the hazard presented by the fixtures (F) is less than the average for the five buildings. On the other hand, the distribution system hazard rating (D) and the pressure hazard rating (P) are

both excessive. In contrast, the fixtures in building "C" in themselves, present over twice the hazard of those in building "B" but the hazard surrounding the entire plumbing installation in building "C" is almost negligible. The reason for this is the very low vacuum frequency.

A continuation of studies of plumbing and its relation to water supply quality and public health will, no doubt, result in new legislation designed to prohibit the installation of defective plumbing fixtures in the future. The effectiveness of such legislation can be estimated by the application of this rating method.

Another application of this plan to corrective measures is in determining the most economical and suitable method of decreasing the hazard connected with the fixtures and installations in a building. For instance, from an examination of the ratings for building "B" it is evident from the fixture hazard rating, F, that the fixtures alone are not the cause of the high building rating. On the other hand, the high distribution system hazard rating, D, indicates that attention should be directed to a consideration of its adequacy and operation.

The rating method should be useful also in determining the priority of corrective measures for the buildings covered. Fixing a building hazard rating limit which will serve to divide the inspected buildings into two groups; namely, one, including those buildings which can be classed temporarily as satisfactory and the other, those which require corrective measures at once, should expedite the initiation and application of such measures.

Although much attention has been given to cross connections between good and questionable water supplies but little thought has been given in the past to the possibility of contaminating the drinking water in the pipes of a structure through weaknesses or flaws in the interior plumbing. Recently this subject has been receiving much more consideration through the efforts of individuals, official agencies and organizations. Hazards to the public health in plumbing have been recognized for some time and special mention is made herein of some of those most likely to be found. Variable factors tend to complicate the study of a building's plumbing system and to secure an accurate estimate of its safety with respect to the health of those exposed to it, these factors must be brought into proper relationship. There is suggested a method for doing this which appears to be sound theoretically but which must stand the tests of time and use.

METERING AS AN AID TO WATER WORKS ADMINISTRATION

By M. F. Hoffman

The primary function of a water works is to provide an adequate supply of pure, wholesome water to its consumers at the lowest possible cost. Many are the complex problems involved in the purification, pumping, distribution, and accounting and collecting procedures. Source of supply, topography of area supplied, various methods of purification required, reservoir storage capacity, and seasonal consumer demand are but a few of the factors which call for the highest calibre of management. It is the objective of this paper to attempt to illustrate the necessity for management to have data, easily obtainable, showing the relation of pumping to distribution and consumption and the billing of and collecting for all water consumed. Since this information can only be obtained by a means of measurement, it will be shown how important a part is played by the measuring device known as the water meter.

There are two means of distributing water through service branches to consumers. One, without meters, known as the flat rate method; the other, through a meter, known as the metered method.

Flat rates (a charge for water based on a front footage, number of openings, or some other arrangement) are merely a guess to arrive at a total amount of revenue which should sustain a water works. There is no control on consumption, as any consumer may use all the water he desires. Leaks, both visible and underground, may be neglected for a long time, with resulting loss to the water works. Unless main trunk line and service branch surveys for leaks are conducted regularly, it will be found that a considerable portion of water pumped will find its way into sewers without bringing in revenue. And since such charges are based on variable items, the

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A paper presented before the meeting of the Finance and Accounting Division at the New Orleans convention, April 28, 1938, by M. F. Hoffman, Commercial Supt., Dept. of Water Works, Cincinnati, Ohio.

cost of inspections necessary for adjustments, and the clerical and accounting expense arising as a result of such inspections, increase the commercial cost of operation greatly out of proportion to revenues received. The flat rate method is not equitable, in that there is no equal distribution of the cost of water. The method appears to be a heritage of the old days when water rents were added to the tax bill. Under this procedure it is almost impossible to plan future improvements intelligently, and the flat rate method of billing water charges appears to be a fallacy.

The water meter may well be called the "cash register" of the water works. The meter registers water used and the consumer pays for this water only. The use of meters, therefore, appears to be the only equitable method of billing charges for water consumed.

It is general water works practice for the utility to assume responsibility for waste from the water main to the shut-off box. From this point to the meter periodical check-ups should be made to avert service branch leaks. Since this line is on private property, the consumer must take care of this maintenance. For the same reason, the meter should be housed as close to the shut-off box as possible, as the meter provides the best possible means for detecting leaks.

Meter routes are laid out so as to provide for the reading of the greatest number of meters with the least effort. However, districts which are comprised of a number of meter reading routes should be arranged to synchronize with distribution systems. This makes possible the control of pumping, distribution and consumption, and facilitates the planning of improvements to meet changing trends of population.

In cities 100 per cent metered there is an absolute management control of production and distribution. We also have a sound basis for fair water rates, which should be arranged according to the quantity of consumption, as it is the usual custom to quote a low net rate to a large steady user, a comparatively small number of whom carry the fixed overhead of the department.

Two questions arise in the metering problem: (1) Shall the water works own, install and maintain meters and add a service charge to the consumer's bill; or (2) shall the consumer pay for and install and maintain his meter and thus avert the service charge?

The first situation involves a large capital outlay which can be amortized by crediting the excess revenues from meter service

charges over the cost of meter maintenance against the original expenditures. This policy requires rigid accounting control, and is not the best method for a close, favorable relationship with the public. Two examples of these conditions are: It prevents the water works from restricting its activities outside of private property, and it confuses the issue as to a fair water rate, as the monthly or quarterly bill includes a meter service charge, the consumer resents the fact that he is paying for something other than the actual commodity, water, that he is purchasing.

Taking up the second situation, we find that when the consumer purchases his meter, which he has installed by a plumber, the meter service charge is eliminated. After this first cost of the meter and its installation, there is no further expense during the life of the meter (usually estimated at twenty to twenty-five years) except the actual cost of repairs in case of frozen meters or those damaged by hot water. To illustrate: A $\frac{5}{8}$-inch meter may cost from $12 to $18, installed, which is the total expenditure. On a meter of this size the annual service charge may be $3.00, and in twenty years the consumer will have paid $60.00. Certainly the property owner, who has carried a heavy burden these last few years, should receive the benefit of being billed only for water, excluding meter service charges.

Previously it was shown how important is the part played by the meter in controlling pumping and distribution. We find that it is the only accurate means of establishing fair, equitable water rates. By proper accounting control, good management has available all of the data necessary to evaluate fair water rates. Capital investment, depreciation and obsolescence, maintenance, operating expenditures thoroughly allocated to the various functions on the one side, and revenues carefully analyzed, on the other side, present the picture which is based on actual facts. With this information at hand, the head of the water department can locate any weakness in his entire set-up.

An illustration of what has been done in Cincinnati depicts the change made in a large number of cities. In 1917 there were 63,000 services in use, to which were attached 45,000 meters, 71.4 per cent. The daily average consumption per capita was 131.7 gallons. A concerted drive was made, and the city was finally 100 per cent metered in 1931. By the year 1937 we had 102,000 services, all metered, with a daily average consumption of 92.3 gallons per capita, a decrease of 42.7 per cent. This proves beyond all doubt that the

unmetered 28.6 per cent of consumers in 1917 were using considerably more water than was necessary and that the cost of delivering water to the tap was thus made needlessly higher. In the final analysis, we want revenue for all water pumped and with allowances only for main trunk line leaks (which may be alleviated by pitometer surveys), under-registration of meters, and water used by the municipality for fire-fighting, sewer cleaning, street flushing, etc.; through metered accounts, we should receive revenues for all water distributed.

With the city 100 per cent metered, meter maintenance should be provided by the establishment of a modern efficient meter shop. The practice of the consumer purchasing his meter has been continued, and the types of meters in service are many. This has necessitated the carrying of an inventory of meter parts for all makes and types of meters. Having in mind the idea of standardization and simultaneously reducing the cost of new meters to consumers, together with the ultimate lowering of repair charges on meters by carrying a smaller inventory of parts, the Cincinnati Water Works inaugurated a policy in 1931 which has done as much to develop a favorable relationship with the public as have two reductions in water rates in the past seven years.

Formerly the property owner purchased the meter through a plumber. As a result of this practice, every type of meter meeting standard specifications went into service, with the resulting large inventory of parts made necessary for repairs. The proper type of meter was not purchased for the correct usage in a large number of instances.

In 1931 the purchase of meters for resale to consumers was started. Specifications for a year's requirements were advertised and the award given to the lowest and best bidder. This policy has been followed annually, and the results have been extremely gratifying. Plumbers, as well as consumers, have cooperated splendidly on this procedure. The former purchase the meter for the consumer at the time application is made for the service branch, and, as the plumber installs the meter, a completely metered service is assured. The consumer purchases, at cost, a meter for replacement where the old one becomes so obsolescent that it can no longer be repaired. Here is where the real saving accrues to the consumer. With the exemption from paying meter service charges for twenty or more years, his only expense becomes the small outlay necessary to purchase the meter for replacement.

Under this arrangement the water works has intelligent control of all meters and is constantly lowering meter repair costs. The meter remaining in one location during its entire life, permits the establishment of a perpetual visible card record which shows every service required for the meter. A chronological record of the consumer's account is built up by the continuous recordings of meter readings, thus making necessary inspection service only where fluctuations of consumption are shown.

Upon the return of the meter books to the office, after the meter readers have covered the routes, the consumption is checked and inspections ordered for "stuck" meters, excess or under-registrations, and the consumers notified of excess consumption. Unusual cases of excess registration are followed up until all leaks are repaired. This service is warmly appreciated by the property owner, who must pay the bill for all water wasted.

After these meter readings have been billed, a total of the consumption of water must prove out with the amount charged. In this maner, management can ascertain exactly where the water is going and how much revenue is derived from each district.

Only recently, metered data has proved its value. Complaint of a serious lack of water in the eastern district of the City of Cincinnati led to a survey to ascertain the need for either increased pumping facilities or enlarged distribution trunk lines. Meter books for this area were analyzed to show the relation of metered consumption to the total of the distribution system. The result was a recommendation for an auxiliary pumping station which will not only take care of the increased demand caused by large residential developments in this district, but which would also serve should the Main Pumping Station be incapacitated through another flood such as made the city "water works-less" in 1937.

Previously it was stated that water rates had been reduced twice in seven years. In 1930 a new consumers accounting system (the stub plan) and quarterly billing were installed, and large savings were effected at once. On May 1, 1931, water rates were reduced 12½ per cent. This reduction of rates was instrumental in increasing the use of revenue-producing water so that rates were reduced a second time on April 1, 1937, about 11½ per cent. And water rates in Cincinnati are among the lowest in the country.

In the final analysis, flat rates are high in unmetered cities, as they must absorb the cost of wasted water. Furthermore, the unnecessary waste of water means adequate sewerage systems which

must be maintained by the public works department of the municipality. In these days of limited revenues, some cities have had to resort to the "sewer rental charge" to maintain these sewers, and such charge is usually based on a percentage of the water used, with a minimum. Cities 100 per cent metered provide better administration of the water works, a sound basis for planning for future needs, lower commercial costs of operation, and a close amicable public relationship.

Discussion by THAD M. ERWIN.* Mr. Hoffman has presented the advantages of metered services in a very able manner, and we believe this type of service will eventually become the universal practice as we find that the larger percentage of the cities today, who are interested in building a sound financial structure, are using their water meters and water consumption as a basis for various commercial and engineering studies.

We agree that the first method as outlined would necessitate a large capital expenditure which many cities are unable to meet; but if this method is not rigidly adhered to, or even if the city is forced to acquire its meters over a considerable period of time, this delay would prevent them from enjoying the advantages of metered service, such as increase in available data and reduction of costs—as well as the development of a better consumer relationship.

In the second method, while I feel that it has some distinct advantages over the first method, I fail to see why the plumbers should be allowed to make the meter installation. These installations are made upon public property. Streets are dedicated and easements and franchises are granted to the public utility for the installation of the main and pipe lines on this public property, so why should a plumber be allowed to make this installation? A meter must be read and inspected regularly in order that the proper billing may be made and proper care of the consumer relationship maintained, and it would appear to me that many irregularities might creep into this service should a large number of plumbers, who are in no way controlled by the water department, handle this valuable service.

We were very much interested in the method by which Cincinnati handled its meter charges and in the findings shown by the final analysis, but we believe that a third method should be presented in addition to the two outlined by Mr. Hoffman.

*Water Sales Agent, Dept. of Water & Power, Los Angeles, Calif.

This third method is one which I believe a large number of cities are using to advantage at the present time, and our own water department has used it for years. We have a 100 per cent metered service in Los Angeles—with 272,865 metered services, and 4,000 intermittent irrigation services where the meter is installed for the time that the service is in use and then removed until required for another irrigation.

Under this method the water department sells the consumer a water service which includes the cost of tapping the main, piping water to the lot line, and setting the meter thereon. The regular charge for an ordinary domestic service is $15 for a $\frac{3}{4}$-inch or $18 for a 1-inch. This service installation is maintained by the water department and belongs to the property for all time. When repairs are necessary through damage incurred directly attributable to the consumer, a nominal charge is made for the repair. There is no monthly standby service charge added to the consumer's bill.

This installation cost covers all charges that might accrue through depreciation, obsolescence, and maintenance. Meter reading, billing inspections, consumer complaints, and inspections in connection with these complaints, are all carried as a charge through the commercial division, and are paid from revenues derived from water sales.

An adequate shop is maintained together with special installation, maintenance, and inspection crews—all employment being controlled through civil service, thereby maintaining a high standard of efficiency.

The consumer calls a plumber to install or repair all plumbing and all lines on his private property up to the meter which, as stated before, is installed on the property line—the water department making no installations beyond this line.

A file is kept on each service, showing the style, number, location, and date of original meter installation, with a complete record of all repairs, complaints, or meter changes in connection with this service. The thoroughness with which these records are kept manifests itself in the completeness of the data available and the continuance of low cost to the consumer.

This same procedure as outlined is carried on through all our various services with the exception of the automatic sprinkler systems, which are also metered, but which carry a ready to serve charge. All commercial costs are included in this charge.

SAFEGUARDING WATER REVENUE

By H. L. Meites

The problem of safeguarding water revenue and eliminating possible loss through faulty registration, slippage and meter tampering is becoming more acute as time passes on. Unless a method is devised whereby a careful, systematic and scientific check-up is possible, especially on large water users, water revenue is bound to suffer considerably.

Naturally, it is difficult to prescribe a cure-all as conditions vary. Every city has its own set-up; some have progressed and kept pace with the times, while others have remained at a stand-still. What may be a perfect safeguard in one instance, may not serve at all in another. Yet if modern methods are applied they will, generally speaking, produce satisfactory results. This suggestion is also applicable to the safeguarding of all moneys collected and the proper and air-tight methods to be employed, which are so essential in a well-regulated and efficiently organized water department.

The city of Chicago may be taken as an example. We have about 450,000 accounts, of which approximately 325,000 are flat rate or unmetered accounts, and about 120,000 metered accounts. In the latter category we have approximately 20,000 industrial accounts, i.e., large users of water.

Most industries have "seasons" during which they operate full capacity and often two shifts, while during certain slack periods they operate only part time.

Now, to ascertain if the water consumption is correctly measured, it is necessary, of course, to compare the present consumption with the consumption and billing of similar periods during previous years, which is in itself a tremendous job from either ledger or stub accounting method and which often leads nowhere.

A better and much more satisfactory method was originated and worked out by J. J. Ellicott, assistant superintendent of water of the

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A paper presented at the New Orleans convention, April 28, 1938, by H. L. Meites, Supt. of Water, Chicago, Ill.

City of Chicago, who was materially aided by R. E. Bell, an expert on office efficiency. The idea is as effective as it is simple. It works smoothly and does the job most efficiently.

A printed sheet in the form of a graph was prepared, showing water consumption by months for 10 years. Accounts, consuming water amounting to $30 per month and over, are listed on these sheets or graphs. A line is drawn which shows the average monthly consumption, and as months go by, before bills are sent out lines are drawn on these graphs showing increase or decrease, as the case may be. The result is a complete and positive visual record which tells a simple yet definite story of how accounts may vary at stated intervals.

Under our previous set-up we could not easily tell if the customer was increasing or decreasing his consumption in comparison with previous years during the same periods. It was necessary, of course, to look up meter readings in several different books in order to be able to make the necessary comparison, which was a laborious task and was, as a rule, very seldom done.

Today, under this new graph set-up, it is not only an easy matter to make comparisons but it is done automatically, at a glance, so to speak. And what's more, the increases or decreases in consumption stand out so boldly that we are forced to make a check-up to determine what causes these increases or decreases. We usually proceed in the following manner:

When the graph shows a marked drop in the consumption of water, an order is issued to make a meter examination. The meter in question is taken out and sent to the meter repair shops for a thorough examination to determine if the meter is registering correctly and if it was tampered with in any way. A new meter is substituted for the time being and when this new meter shows an increased consumption in comparison with what the old meter registered for the same period of time, an estimated back-bill is sent for the difference of the amount between the old meter which did not register correctly and the new meter installed.

Of course, we cannot give the consumer any credit for such an abnormal increase due to leaks because under the ordinance we must charge for all water that goes through the meter irrespective of whether the water was actually used or wasted.

On the other hand, when the graph shows an abnormal increase in consumption as compared with a similar period of former years, we do not let it go at that. We institute the same careful check-up

as when the consumption shows a decrease. We want to know what causes this sudden increase. We make a thorough inspection for possible underground leaks, leaky water fixtures, defective plumbing, or similar defects causing loss of water. We advise the water consumer of our findings and urge him to make all necessary repairs, thereby reducing the consumption to normal. Our inspection may also disclose that the increase is caused by additions to the plant, or increase in machinery, or similar causes which prove that our graph was a correct indication of such increased consumption.

It is also important that money collected in payment for water should be carefully guarded and accurately and expeditiously accounted for. While the human mind is frail, it is also cunning, and no matter what safeguards are made to prevent defalcation by employees it is found, now and then, that some so-called trusted employee will be able, by sheer cunning and scheming, to evade all safeguards and carry on his defalcations without being discovered—at least for a long time.

Where the ledger and stub system is used it is possible for a receiving teller to hold out money for several days and carry on his peculation undetected, by a very simple method. Some of the larger concerns make it a rule to pay water bills many days before they become due, to be sure to get the discount allowed. This is a fine practice and should be encouraged. But in spite of all our pleadings and urgings to send in the entire bill—not just the stub—with their remittance check, they persist in doing just the contrary. They believe that a canceled check in payment of a water bill is the best receipt, which in practical application is correct. This practice of sending in only the stubs with check payments is being encouraged by all the utilities, which means to them a substantial saving in postage by not returning receipted bills. Municipally-owned water works should not be eager to save postage by not returning paid water bills; it is poor economy at best, and sometimes proves a costly practice.

The dishonest cashier may hold out checks and stubs received prior to due dates and on the day the bill becomes due he pays it in order not to lose the discount and thus start an investigation. True, it is a laborious effort but it has been done in many instances and it takes months and sometimes years of such manipulations before the dishonest and scheming cashier is discovered.

And again I can boastfully say that we in Chicago have a system

so perfected that it absolutely eliminates any possible chance for defalcation.

We receive about 1,500 remittances a day by check through the mails. Every check, with the bill or bills that accompany it, is photographed by the Recordak system, thus tying up every check payment directly with the bill, or stub, for which the payment is made.

The Recordak is a very simple machine. It photographs at high speed on narrow width motion picture film. It is practically automatic in operation. The operator feeds the bills into a feeding hopper—much as a mimeograph or multigraph is fed. The Recordak automatically photographs them and ejects them in original order. No special knowledge or experience is necessary. The timing of the photographic exposure, lighting, and all other details of the photographing process are automatically taken care of by the machine itself. It is simple, rapid, and accurate. It gives us a complete record of every transaction every day, which records are filed consecutively, thus giving us the opportunity to check back any transaction when that necessity might present itself.

Furthermore, we have in the Chicago Water Bureau two sets of cashiers—those who receive only check payments and those who receive only cash payments—which completely eliminates all chances of the manipulation of funds as above mentioned. Both are separately balanced. No employe will ever dare take a check payable to the water office and appropriate it for his personal use, because he knows that he will never be able to cash it. The cash-payment cashiers must give receipts for every penny they receive and at the close of the day their cash is balanced by an official auditor authorized to do so. This method again precludes any possibility of holding out any of the receipts or cash fund or of cashing checks or manipulating stubs. In our office this system works smoothly and perfectly, giving absolute security and safeguarding all moneys collected in payment for water.

Each cashier has his own locked cage and receiving window and immediately adjacent thereto is an assistant (called a registrar) who has a separate cage and window.

The cashier receives the payment from the customer and perforates the stub with his plate, passes the bill and stub (attached) to his registrar who perforates and receipts the bill, cuts the stub and registers the amount paid upon a blind list and locked total control machine.

The customer receives his receipt from the registrar. When closing time arrives the official auditor steps into the registrar's cage and unlocks the control machine, takes a total and removes the printed tape. The auditor then enters the cashier's cage and balances the cash with this total (which is unknown to the cashier) and also balances the cash change fund. If these are all right, the money and balance are locked in the vault.

In the meantime, the registrar has delivered the stubs (which have been detached from the bills) to the bookkeeping department where audit sheets are run of the cashier's total and posting pre-control totals. This proves the accuracy of the official balance of the cashier and sets up split totals for control of the posting of payments to the individual ledgers and to the general ledger.

I am presenting these facts and experiences of the Bureau of Water in Chicago because they serve a definite purpose in which we are all so much interested.

ABSTRACTS OF WATER WORKS LITERATURE

Key. **29**: 408 (Mar. '37) indicates volume 29, page 408, issue dated March 1937. If the publication is paged by issues, **29**: 3: 408 (Mar. '37) indicates volume 29, number 3, page 408. Material inclosed in brackets, [ ], is comment or opinion of abstractor. Initials following an abstract indicate reproduction, by permission, from periodicals as follows: *B. H.—Bulletin of Hygiene (British); C. A.—Chemical Abstracts; P. H. E. A.—Public Health Engineering Abstracts; W. P. R.—Water Pollution Research (British).*

WATER SUPPLIES—GENERAL

Shanghai (China) Waterworks Co., Ltd., Annual Report, 1937. C. D. Pearson. Av. daily demand was 43 m.g.d., decrease of 2.34%, chiefly attributable to local hostilities. Max. daily demand was 60 m.g.d., ratio of av. to max. daily consumption being 1:1.4, ratio of av. hrly. demand to max. was 1:1.97. Av. turbidity of raw Whangpoo R. water was 155.6 p.p.m. and coeff. of fineness 0.95: av. alum dosage was 0.948 g.p.g. and av. of settled water 21.47 p.p.m. Slow sand filters produced 28% of total output and rapid sand filters 72%. Av. no. of days between cleaning of slow sand filters was 15.28 and av. rate of filtration 1.63 gal. per sq. ft. per hr. All water applied to rapid filters was prechlorinated, av. dosage being 0.981 p.p.m.: av. rate of filtration was 100 gal. per sq. ft. per hr. and wash water averaged 2.61% of water filtered. Cl_2 applied at the 2 post-chlorination points, rapid sand filters and main engines, averaged 0.359 and 0.218 p.p.m., respectively. Quality of water leaving plant was highest ever recorded, coliform bacteria being absent in 99.8% of the samples in amounts less than 100 cc. Of 1625 samples of delivered water examined, 95.3% were negative for coliform bacteria in 100 cc., 3.4% positive in 100 cc., 1.0% in 10 cc., and 0.1% in 1 cc. No. of complaints received averaged 4.4 per mil. of pop. supplied: only 5 complaints had reference to potability and 9 to living organisms in the supply, latter being largely due to larvae of aquatic fly, *Diptera Chironomous*. Detailed data are given regarding efficiency and cost of operating various pumping units. Cost of pumping per mil. gal. was $3.23 for primary units (river to settling tanks), $7.59 for secondary units (settling tanks to filters) and $16.24 for main units (filters to consumers). Cost of steam per 1000 lb. was $1.1967: overall thermal efficiency of boilers was 59.6% and B.t.u.'s consumed per lb. of steam averaged 2,002. Total of 1,541 meters were repaired and reconditioned and 4,350 overhauled: repair cost per meter was $7.63 compared with $5.44 in '36, increased cost being largely due to disruption of normal routine of meter shop and large no. of meters recovered from burnt-out areas in zone of hostilities. Total no. of hydrants maintained was 2,355, cost of maintenance being $11.45 per hydrant. Brief interesting account is given of effect of hostilities on operation of co.'s works and of precautions observed. In addition to permanent strong points

constructed under military advice 5 yrs. previously, exposure of staff to rifle and shell fire, shrapnel and bombing made essential provision of sandbag redoubts and splinter-proof shelters: 40" diam. steel pipes were also distributed around compound to serve as temporary shelters. Three Chinese employees were killed and 14 others accidentally wounded during removal of snipers from adjoining factory. Four bombs and 8 shells which actually exploded in works caused no injury and damage was neglible. Co.'s 193.2 mi. of mains suffered relatively little. Fire in Yangtszepoo district, laying waste 1½ sq. mi. of highly developed property, resulted in enormous loss of water through broken pipes,—as much as 15 m.g.d. Shutting off services and removing meters in area, which was occasionally subjected to rifle and shell fire, was trying work. Schemes were prepared in detail for utilizing private wells or, as last resort, raw river water in event of complete interruption of supply. Floating steam-driven plant was secured for obtaining water from river. [Under such conditions, the efficiency of operation, the excellent quality of the water supplied, and the promptness and completeness of the annual report is remarkable.]—*R. E. Thompson.*

Erie, Penna., Bureau of Water, Annual Report, 1937. Officials include C. R. Barber, Director (also Mayor) and James S. Dunwoody, Gen'l Sup't. Erie (pop. 123,000) is served by municipally owned water works taking water from Lake Erie, works constructed in 1867 and reconstructed in '12–'13 with additional auxilliary plant built in '32. Steam and electric power used for pumping, 7,328 mil. gal. pumped by steam, 1,652 mil. gal. by electric power in '37. Av. cost per kw. hr. was 0.943¢. No. of gal. per lb. of coal, 389. Total income was $667,415; $650,654 from sale of water, an increase of $25,062 over '36. Total consumption 8,981 mil. gal. of which 4,311 mil. gal. passed through meters; av. consumption was 24 m.g.d. with 205 gal. per day per capita. Cost of supplying water was $31.259 per mil. gal. Size of mains ranges from ¾" to 48", total now in use—273 mi. with nearly 7 mi. less than 4"; 1,497 fire hydrants in use. 4,117 gate valves now in use, 94 added in '37. Galv. wrought iron, c.i. and copper services used, ¾" to 16" in size; 32,247 total with 26,170 in use; av. length—16' 9", av. '37 cost—$29.73. Meters in use 1,226 with 25 placed in yr., 4.7% of services being metered from which 30.58% of receipts are received. Two purification plants treat water; Chestnut St. plant with 16 filter units has capacity of 32 m.g.d., West Plant placed in operation in '32 has cap. of 16 m.g.d. and is first unit of ultimate 70 m.g.d. cap. plant. Water treated with av. of 0.228 g.p.g. alum; 1.50 lbs. chlorine and 2.86 lbs. carbon per mil. gal. Wash water 2.09%. Raw water of low av. turbidity, approx. 95 p.p.m. alk., no positive coliform group tests found in 916 treated water samples.—*Martin Flentje.*

Reliable Water Service. W. W. DeBerard. Eng. News-Rec. **121**: 169 (Aug. 11, '38). Water works practice in Madison, Wis. (65,000 pop.) is reviewed. System supplied from wells drilled 750' to Potsdam sandstone, which outcrops in vicinity of Wisconsin Rapids: as rate of percolation is 1" per hr., it appears that water now being pumped fell as rain 2000 yrs. ago. Air lifts raise water to reservoirs near wells, whence it flows by gravity to main station

or is pumped directly to mains. A 6-mil. gal. circular concrete reservoir on highest hill in town rides on system: pressure is 85 lbs. at pumping station. Not a single positive coliform test has been obtained on water in 12 yrs. Hardness is 18–20 g.p.g. Stations are attractive inside and out: it has been found that 8% added to cost of bare utilitarian requirements will produce plant which is civic asset. Past practice was to lay mains with 6′ cover: in '35–'36, frost penetrated lower than 6′ in places. Mains, 145 mi., are of c.i., 3″–30″ in diam.: present practice is 6″ min. Water is non-corrosive: pipe laid in 1882 still in first class condition. There are 2500 valves and 1200 hydrants. Not more than 2 blocks can be affected by main failure: it is planned to reduce this to 1 block. Hydrants are installed at least at every corner in 500′–660′ blocks. Fire dept. is notified when hydrants are out of commission: not in 30 yrs. has dept. unexpectedly found a hydrant unusuable. Hydrants are inspected at least twice each yr. and valves at least once in 2 yrs. City furnishes all meters. Program to bring all meters to shop once in 4 yrs. was inaugurated but found unnecessary. After test and repair, meters are set to read between 62 and 63 lbs. for 1 cu. ft.: on $\frac{1}{32}$″ stream, 90% accuracy is required. Meters invariably run slow after use. In case of plumbing leaks, customer pays for av. consumption as usual and remainder is charged at lowest rate in schedule. Large no. of older meters were discarded 5 years ago, reducing no. of types and makes from 28 to 4. Per capita consumption is about 120 gals. per day. Of this, 83% is registered by consumers' meters, 6% is public consumption (also metered), 5% is used in hydrant flushing and for station purposes, and 6% is unaccounted for: latter has been reduced from 23% since '18. Output cost of water is about 5¢ per 100 cu. ft., compared with 6.5¢ in '18. Meters are read at least every 2 mo. Complete system of records and accounts is maintained. Roughly, net worth of plant is $3,000,000 and funded debt $150,000. Dept. operates as separate utility paying interest of $91,000 (4.5% on equity which city has in plant), taxes to city of $39,000 (same as if private co.), and $30,000 toward amortization of city's funded debt. for water dept. Total revenue is $400,000 and operating expenses $175,000, leaving $30,000 for depreciation and in addition $35,000 balance to be reinvested in plant. Meter rate is 7.5¢ per 100 cu. ft. for first 75,000 cu. ft. and semi-annual demand charge of $2 for $\frac{5}{8}$″ meter. Customers outside city limits pay 33⅓% higher rates.—*R. E. Thompson.*

Ground Water Supplies in Florida. V. T. STRINGFIELD. Civ. Eng. **8:** 457 (Jul. '38). Ground water is one of Florida's most valuable natural resources. About 240 communities in the state have public water supplies and fully 210 of these obtain their water from wells. In addition several thousand flowing wells used for irrigation of celery and other vegetable and citrus crops. Geological formations which yield ground water supplies include the Ocala limestone and younger formations. Former underlies entire state, dipping from the surface at 150′ above sea level in NW. portion to more than 1,000′ below sea level, with thickness of about 500′. In some parts of state the limestone is cavernous. Tampa limestone, which is about 200′ thick, is at or near surface in west-central and northwestern parts of the peninsula. The formation is in general more compact and less permeable than the Ocala. The Hawthorn

formation is present throughout the state except where older rocks are exposed. It rests on the Tampa limestone or on the Ocala limestone, and is generally overlain by younger materials. It prevents or retards upward escape of artesian water in the Tampa and Ocala limestones. Chief source of artesian water is probably rainfall within the state and southern parts of Georgia and Alabama. Principal ground water problems of the state include: (1) decline in head and yield of wells in areas of large draft from wells, (2) subsurface leakage out of wells, (3) surface drainage by means of wells, (4) contamination of fresh ground water by salt water, and (5) occurrence of ground water containing objectionable amounts of fluoride. Although there is abundance of ground water in Florida there is need of careful planning of its development and conservation.

Discussion. CHARLES E. REICHHEIMER. *Ibid.* 8: 553. (Sep. '38). By extending casings of three old wells from 12′ to 500′ below the surface, flow from one well was halved, from another greatly reduced, and from a third was unaffected in either quality or quantity. Quality of water from two of the wells much softer after deepening the casing. There were discrepancies in the laboratory reports on fluoride content of the water, one reporting increase and the other decrease after deepening the casing. Evidence indicates some inter-communication between all wells involved in a development at Fernandina, Fla., and that there must be a layer of impermeable material under the saline water in nearby rivers. Results of work in Fernandina and Sarasota indicate that straight-line relationship between artesian head and saline infiltration must be modified in case of Fla. artesian supplies to take into account other complications.—*H. E. Babbitt.*

Water Problems in Florida. A. W. FISCHER. Civ. Eng. 8: 617 (Sep. '38). Although Florida presents no wide range in topography it does have marked differences in surface runoff. With expansion of industry there will be demand for information concerning surface runoff lack of information concerning which has already had disastrous results on a number of construction projects in the state. When the inseparable relationship between surface water and ground water is properly appreciated it may be possible to solve problems arising in surface water studies. Necessity for treatment of water and guarding against overdraft are apparent in the state.—*H. E. Babbitt.*

Industrial Waters in Canada. HARALD A. LEVERIN. Interim Rept. No. 3. Can. Bur. of Mines, Memorandum Series No. 68 (Jul. '38). Analyses made in '37 in continuing investigation of quality of waters used or available in Canada for industrial purposes. Area extended to include whole of Canada. Complete analyses given of 49 surface waters from key stations on large lakes and rivers of industrial importance, together with partial analyses (alkalinity, total, calcium and magnesium hardnesses) for 84 public water supplies. Following discussion of quality of waters in various sections of country, effect of impurities in water used in following industries is dealt with at some length: mining, silver plating, yeast manufacture, pulp and paper milling, textile processing, felt hat manufacture, soap production, ice manufacture, brewing, and distilling, tanning, sugar manufacture, baking, canning, starch manu-

facture, glue manufacture and steam raising. In discussion of rôle of dissolved oxygen and carbon dioxide in corrosion by water, it is pointed out that while normally 10 p.p.m. oxygen could oxidize only 31 p.p.m. of iron, in combination with carbon dioxide it will oxidize 126 p.p.m. Final product is Fe_3O_4. When all dissolved oxygen has been used up, nitrates are reduced to ammonia, supplying additional oxygen.—*R. E. Thompson*

New Water Supply for Salt Lake City. ANON. Eng. News-Rec. **120:** 899 (Jun. 30, '38). Present supply, averaging 28.3 m.g.d., derived from canyons adjacent to city: ⅓ from sources owned outright and remainder through 25 exchange contracts whereby domestic water is secured either for cash or exchange of culinary or irrigation water (mostly polluted) from Utah Lake. Ground water source was developed in '34, driest yr. on record, to augment supply. About 148,000 people in and around city are supplied and present requirement is 32.6 m.g.d.: in '80 it will be 68 m.g.d. Last fall, voters approved Deer Creek project, combination irrigation and domestic supply project. U. S. Bur. of Recl. has accepted responsibility of providing storage reservoir on Provo R. and bringing water to city through 40-mi. conduit. City's share (46% of cost of project exclusive of aqueduct + full cost of aqueduct) is to be repaid on terms of reclamation law—payment over 40 yrs. without interest. Normal yield of project is 100,000 acre-ft., in which city would have 46% interest at estimated cost of $3,371,294. Sale of surplus water for irrigation until required for domestic purposes is contemplated. Annual cost to city is estimated at $223,000, not much more than half of cost of several other available sources, some of doubtful purity. Project consists of earthfill dam, 155′ high and 1400′ long on top, forming 150,000 acre-ft. storage reservoir, 390′ higher in elevation than Salt Lake Park Reservoir and 570′ above Parleys Reservoir, where filters are ultimately contemplated. As all water in Provo R. has long been appropriated, storage will come from Weber R. by enlargement of existing diversion canal and from Duchesne R. (Colorado R. tributary) by transmountain diversion through 5½ mi. tunnel. A 66″ concrete conduit, 40 mi. long, is planned to bring 130 sec.-ft. from reservoir to city system at estimated cost of $5,500,000. Coupled with project is proposal to dike off shallow portions of Utah Lake for purpose of diminishing evaporation losses. Proposed to increase normal yield of lake by 60,000 acre-ft., of which city would receive ⅓ at estimated cost of $20,000 annually. Irrigation water now obtained from Utah Lake to fulfill exchange obligations by which mountain creek water is utilized for domestic consumption. Rate increases of 33% considered necessary to finance city's portion of projects.—*R. E. Thompson.*

How Nashville Serves Suburban Customers. R. L. LAWRENCE, JR. Pub. Wks. **69:** 9: 9 (Sept. '38). Water-works Dept. of Nashville, Tenn. (pop. 154,000, metropolitan area 215,000) supplies 34,000 customers in corporate limits and approx. 6000 outside. Water obtained from Cumberland R. with watershed of 12,500 sq. mi., treated in 42 m.g.d. capac. plant using aeration, coag., settling, filtration, chlorine-ammonia sterilization. Capac. pumping equipment 40 m.g.d., in duplicate. Output averages 20 m.g.d. through 464 mi. of main, 358 mi. in city, remainder outside privately owned. Rates within city

allow 1000 cu. ft. per quarter for min. of $1.50, rates outside city double this. Private lines outside city laid under Dep't regulations and inspection, which include: pipe must be tested class 150 centrifugal or equiv. bell and spigot c.i. 12′ or 16½′ long (sometimes 18′) under 30″ cover. New mains sterilized using calcium hypochlorite, ⅛ oz. for 3″ pipe, ¼ oz. for 4″, ½ oz. for 8″, to 3 oz. for 24″ per length based on 12′ pipe lengths. Services must be at least ¾″, those under 1″ are full lead; those from galv. iron mains may be lead or galv. iron, but with 18″ flexible lead between main and service. Over 1″ and below 3″ genuine wrought iron used. No meters larger than 2″ used, batteries used if 2″ not large enough. Consumers in city furnish all meters over ⅝″, consumers outside city furnish all meters.—*Martin Flentje.*

RATES AND FINANCING

Flat Water Rates—Domestic. Anon. W. W. Inf. Exch., Canadian Sect., A.W.W.A. **2**: B: 3: 14 (May '38). Tabulation given of annual water rates in Canadian municipalities in which charges are made on flat basis, together with billing periods and discounts allowed for prompt payment. Charges classified under following headings: sinks or taps, baths, basins, toilets and laundry tubs; in each case, except latter, columns are included showing rate for 1 fixture and for extra units. These data are too extensive to be abstracted. In some cases, rates are based on no. of rooms in dwelling, no. of inmates, assessed value of property, etc. Billing period in 3 instances is 1 mo., in 12 two mos. in 46 three mos., in 14 six mos., and in 6 twelve mos. Discount, given for 38 communities, is 5% in 2 cases, 10% in 26, 12.5% in 1, 15% in 1, 20% in 5 and 30% in 2. In 1 municipality, discount of 12¢ per room is allowed.—*R. E. Thompson.*

Flat Water Rates—Lawns and Gardens. Anon. W. W. Inf. Exch., Canadian Sect. A.W.W.A. **2**: B: 4: 20 (Jun. '38). Tabulated data are given regarding charges made for watering of lawns and gardens in various municipalities in Canada. Rates vary widely, based upon area to be watered, type of appliance used, etc. In few instances, flat charge is made irrespective of area of lawn.—*R. E. Thompson.*

Flat Water Rates—For Building Purposes. Anon. W. W. Inf. Exch., Canadian Sect. A.W.W.A. **2**: B: 5: 23 (Jun. '38). Charges made for water used for building purposes in Canadian municipalities are tabulated, classified under following headings: per 1000 bricks, per cu. yd. of concrete, per 100 sq. yd. of plastering, per cord of stone and miscellaneous. Av. for first 4 items are, respectively, 10.6, 6.2, 27 and 13.5¢.—*R. E. Thompson.*

Rate Structures. Theodore L. Bristol. J.N.E.W.W.A. **52**: 70 (Mar. '38). Former flat rate method of charges for water service now largely displaced by meter rates. Steps necessary to detn. fair return on water works property on which rate structure based are to ascertain value of property, detn. working capital, cash and supplies and find going value. Following this by adding fair return, taxes, depreciation and all other expenses, gross return can be computed. Fire protection charges hard to determine. Article quotes Met-

calf, Kuichling and Hawley (Proc. A.W.W.A. 1911, p. 55) recommending charges which were per cent of gross revenue chargeable to fire protection, varying from 77% in town of 5000 to 13% in city of 300,000. Wis. Public Utilities Comm. (J.A.W.W.A. **25**: 75 (Jan. '33)) has established fair rate for fire protection of $1.25 per yr. per capita. Ansonia, Conn. rates for water given, vary from $0.20 per 100 cu. ft. for 1st. 2000 cu. ft. per meter per quarter to $0.06 for same quantity for 1,000,000 cu. ft. Fixed service charge ranges from $1.50 for ½" to ⅝" meter to $216.00 for a 10" meter.—*Martin E. Flentje.*

Financing Sewage Disposal by Rentals. CARL W. FRANK. Minnesota Municipalities **23**: 136 (May '38). The growing practice of raising at least part of annual cost of sewerage and sewage-disposal systems by charging those making use of the sewers is a subject touching closely on water works because in many cases sewer rentals are based in some degree upon amount of water used. Thirty-two states have passed acts enabling some or all of their municipalities to charge sewer rentals. In seven other states sewer rentals being charged under charter provisions or general laws. Minnesota enabling act of '35 authorizes any city other than first class and villages to charge sewer rentals, taking into account quantity and concentration of sewage and cost of disposal. Charges shall be based on quantity of water consumed or any other equitable plan the governing body may choose, and may be "a surcharge on the water bills of all water consumers in the municipality on the grounds that said sewage treatment is for the purpose of preventing pollution of sources of water supply." Sums received from sewer rentals and from by-products of sewage treatment shall be placed in a separate sewer or water fund, to be used first to meet charges of operation and maintenance and after that to meet capital charges or cost of replacement and obsolescence. Throughout the country there are three plans for sewer rentals: (A) Water consumption; (B) flat rate, varying by classes of residence, business or industry, or number and kind of fixtures; (C) character of sewage. Plan A said by author to be most equitable one where all or most of water is metered. Where it is used the rates, in a group of cases, range from 2 to 40¢ per 1,000 gal. and average about 14¢ and are from 100 to 100% of the water bills, averaging from 40 to 45%. Ready-to-serve charges, where used, range from 10¢ to $1 a month, with av. about 30¢. Where flat rates prevail av. of some of monthly schedules is: kitchen sinks, 20¢; lavatories or laundry tubs, 5¢; bathtubs, 10¢; private toilets (not defined), 20¢. Residence charges per month, in a group not described, average: single family, 60 to 75¢; apartments, 30 to 40¢ per family.—*M. N. Baker.*

Relative Value of Utility Systems. C. F. LAMBERT. Eng. News-Rec. **120**: C-16 (Jun. 30, '38). Tabular and graphical data are given on value trends of 5 types of utilities (water works, electric light plants, street railway systems, natural gas plants and artificial gas plants), bringing up to Jan. 1,'38 data originally published in Eng. News-Rec. May 7, '25 and brought up to date annually since '31. Additional plants have been added in making computations until now about twice as many are now used as were originally. Av. yearly values are compared with av. values in '13 and in '26 as bases. Relative

monthly values in '37 are also given. In computing value of water works, 25 systems were used: items considered included land (maintaining value constant), buildings, equipment (boilers, pumps, etc.), distribution (pipe, valves, hydrants, meters, standpipes, reservoirs, filters, etc.) and miscellaneous (furniture, tools, automobiles, etc.). Cost of construction of water works in '37 was 104.3 compared with values in '26 taken as 100, and 195.5 compared with values in '13 taken as 100. Monthly data for '37 show definite rise during first 3 months from 184.7 in Jan. to 197.1 in Apr. ('13 = 100): Dec. figure was 198.2.—*R. E. Thompson.*

CHEMICAL

Technique in the Determination of Dissolved Oxygen. T. H. DAUGHERTY. Proc. A.S.T.M. **37**: Part II: 615 ('37). Procedure as described employs the Winkler principle of fixation and titration and the Schwartz and Gurney principle of double titration to cancel introduced errors. Sampling technique using hot water to first flush bottles for removal of air before collecting sample is described. Greater sensitivity and accuracy is claimed for the whole procedure as a field method. An all-glass one-piece sampling flask with inlet, overflow, and reagent tubes is described in the discussion by C. H. Fellows and J. M. Raynor (p. 627).—*T. E. Larson.*

Automatic Recorder for Oxygen in Water. A. PETERSEN. Arch. Wärmew. **18**: 165 ('37); Sci. Abstr. B. **40**: 443 ('37). Dissolved oxygen in water is determined by immersing the positive pole of a galvanic cell in a saturated salt solution, and the negative pole in the water to be tested. A galvanometer or recorder connected across the poles indicates the rate of oxidation of nascent hydrogen by the dissolved oxygen; the deflection is proportional to the oxygen content up to 4 mg. per liter and a calibration curve is used for higher values. The temperature and rate of flow must be strictly controlled. About 20 plants have now been installed in Germany. The plant must be protected from vibration, heat and dirt. Copper tubes must not be used when the water contains dissolved sulfite. The positive electrode and porous plate must be cleaned at intervals varying from 1 mo. to 1 yr. A modified apparatus for the determination of dissolved oxygen in sulfite waters is described.—*W. P. R.*

Testing of a Recording Oxygen-Measuring Device. A. SPLITTGERBER. Vom Wasser **12**: 173 ('37). The instrument of the Chlorator-Gesellschaft was tested by comparing values indicated by it with those obtained by chem. analysis of the water just after it had passed through the instrument, all necessary precautions being taken to avoid absorption of O_2. A "deoxygenated" water was used for the comparison. The mean deviation between the 2 sets of values was exactly 0, the greatest pos. deviation from the chem. results being +0.03 p.p.m. and the greatest neg. deviation— −0.02 p.p.m. To obtain consistent readings a const. flow through the instrument must be maintained. A reduction of 1 liter in a flow of 12 liters owing to partial stoppage of the effluent valve of the instrument resulted in a decrease of 3.5 scale divisions in a scale reading of 30 divisions. Instrument is designed for a water temp. of 24°. A fall in temp. of 1° resulted in a decrease of 1 division in a 30 division scale reading.—*C. A.*

A Photoelectric Method of Measuring pH Values with Indicator Solutions. G. F. Lothian. Trans. Faraday Soc. **33**: 1239 ('37). A method of determining pH values is described whereby the light absorption of an indicator solution is measured over a band of wave-lengths transmitted by a filter. The method of choosing the best filter for use with an indicator and the conditions for obtaining the greatest precision are explained. Results obtained with various indicators are given. The measurements were made with the Hilger Spekker Photoelectric Absorptiometer. This consists of a light source, color filter, test solution, photoelectric cell of the rectifier type and galvanometer. The indicators were used in concentrations of ½ cc. of the standard commercial indicator solution in 10 cc. The mean precision of pH determination obtained varied from 0.02 to 0.04. The method can be extended to determine the pH values of colored solutions by measuring the light absorption of solution plus indicator compared with that of the solution alone. The calibration with standard solution needs only to be made once. The method does not depend on visual matching of colors and has a good degree of accuracy. Since a photoelectric instrument is most accurate for small light absorptions, a small quantity of indicator is sufficient to give accurate measurement. This is an advantage in measuring weakly buffered solutions where the addition of indicator may change the pH value being measured.—*W. P. R.*

Significance of Hydrogen Ion Concentration and pH Values. Daniel J. Bengolea. Bol. Obras Sanitarias Nacion (Buenos Aires) **2**: 531 (May '38). Article presents a brief discussion of the electrolytic dissociation theory to explain the existence of positive and negative ions in water solutions as an introduction to a mathematical presentation of the ionic equilibrium existing in solutions of strong acids, weak acids, strong bases and weak bases using the familiar Law of Mass-Action equations. By working a numerical example, the authors show the advantage of using the logarithm of the reciprocal of the hydrogen ion concentration (the pH) instead of the hydrogen ion concentration itself to express the intensity of acidity or alkalinity in water solutions. The "buffer" action or the resistance offered to pH variations by certain salts is explained through a discussion of the mechanism by which the hydrogen or hydroxide ions added to the solution are used up by the salts of weak acids and by those of weak bases to form slightly dissociated acids and bases thus preventing abrupt changes in the hydrogen ion concentration. Finally, the theory and practice of pH measurement by potentiometric and colorimetric methods are presented.—*J. M. Sanchis.*

Determination of Hardness in Water by Direct Titration. R. T. Sheen and C. A. Noll. Proc. A.S.T.M. **37**: Part II: 609 ('37). A comparison of gravimetric, palmitate, and Clark's soap method (with and without neutralization) for determination of total hardness shows (1) general good agreement between gravimetric and palmitate methods (3–6 p.p.m. variation), (2) slightly better results with palmitate than with Clark's method on neutralized samples, (3) and improvement in Clark's method by neutralization particularly in lower concentrations of hardness.—*T. E. Larson.*

Modification of Blacher's Method for the Determination of Hardness of Water. HALVARD LIANDER AND LENNART SIMONSSON. Iva p. 45 ('38). Blacher's method has been modified as follows: To 100 cc. of H_2O add 1 cc. of an indicator soln. contg. 0.025% bromocresol green, 0.025% metacresol purple and 0.05% xylenol blue. After titration for carbonate hardness with 0.1 *N* or finally *N*/28 acid to a yellow color, air is blown through the sample for a few min., 0.1 *N* NaOH is added until a green color is obtained, and it is finally titrated with *N*/28 K palmitate soln. until the first color change to blue-violet. The total hardness thus obtained is corrected by subtracting 0.2 cc. K palmitate.—*C. A.*

A Contribution to Water Analysis. W. H. KITTS. Analyst (Br.) **63:** 162 (Mar. '38). Determination of total dissolved salines in water by measurement of electrical conductivity is of considerable accuracy if approximate proportions of bicarbonate, carbonate, chloride, sulfate and nitrate are known. Obviates errors of unknown residual water of crystallization and of organic matter which are incident to more usual evaporation and weighing. Influence of free carbon dioxide negligible but silica must be determined separately Method of calculation is given. Blacher's palmitate method of hardness determination is considered simplest and most reliable. To overcome indeterminate end point with magnesium a blank with distilled water is titrated with palmitate to strong red color with phenolphthalein (0.6–0.8 ml.) test solution is then titrated to this shade and blank subtracted, if necessary giving blank same turbidity as sample with acid free kaolin. Accuracy of palmitate method is such that, with ordinary waters containing no interfering substances, magnesium may be calculated from difference between total hardness and lime precipitated as oxalate and titrated with permanganate. If iron, aluminium and zinc are present palmitate titration must be made in slightly acid medium, blank being given same acidity. Clark's hardness method considered tedious and somewhat unreliable, Wartha-Pfeiffer's useful only with fairly hard waters and even then results slightly low.—*W. G. Carey.*

Modification of the Palmitate Determination of Magnesia in Water. P. HAMER AND H. E. EVANS. J. Soc. Chem. Ind. (Br.) **56:** 441 T (Nov. '37). To overcome indefinite end point when titrating magnesium hardness with palmitate recommended that magnesia be precipitated by sodium hydroxide, sodium aluminate being added as coagulant. 100 ml. of water is neutralized to methyl orange, two drops of the 0.1 *N* acid being added in excess and carbon dioxide expelled by boiling. Phenolphthalein, followed by 6 ml. of 0.1 *N* sodium hydroxide in excess of that required to produce pink color are added, boiling is continued for one min. in covered beaker, and after addition of 1 ml. of 0.28% aluminate solution liquid is quickly cooled. Cold solution titrated with acid until pink color just disappears, then with palmitate solution until first definite re-appearance of pink. Further 0.1 ml. of palmitate then added, if color is then deep pink, first reading is correct end point.—*W. G. Carey.*

A Colorimetric Method for Determining Magnesium in Water. R. SCHMIDT AND G. GAD. Kleine Mitt. Ver. Wasser-, Boden-u. Lufthyg. **13:** 326 ('37).

Authors discuss methods of determining magnesium in water, and describe a procedure for determining it by means of the red color produced with titanium yellow in presence of sodium hydroxide. Calcium found both to deepen and stabilize the color. Methods of preventing interference due to ferrous iron, manganese, aluminium, zinc and copper are described.—*W. P. R.*

The Volumetric Estimation of Calcium and Magnesium. O. Pročke and J. Michal. Collection Czechoslov. Chem. Commun. **10:** 20 ('38). Fox proposed method in which Ca is pptd. as CaC_2O_4 and Mg as $MgNH_4AsO_4 \cdot 6H_2O$ in presence of one another. Well-washed ppt. was dissolved in dil. H_2SO_4 and oxalic acid titrated with $KMnO_4$, after which arsenic acid was titrated iodometrically. With slight modification, method has proved better than F. claimed. Recommended that 0.15–0.2 gram of sample be dissolved in 3 ml. dil. HCl and 10 ml. 10% NH_4Cl, 50 ml. 2% $(NH_4)_2HAsO_4$ and 0.2–0.3 gram oxalic acid added. After dilg. to 150 ml., general procedure of F. is followed. Not necessary to use empirical factors for calcg. results.—*C. A.*

The Determination of Fluorine in Water. Rogelio A. Trelles and Nicolas M. Salas. Bol. Obras Sanitarias Nacion (Buenos Aires) **2:** 495 (May '38). The fact that the fluoride results obtained by the direct colorimetric technique of Sanchis may be affected by the presence of excessive amounts of interfering substances in the water, led to search for a more generally applicable method with which to check the figures previously obtained in a survey of fluoride bearing waters in Argentine. As result of investigation of available procedures, the technique outlined in J.A.W.W.A. **28:** 1466 (Oct. '36) was adopted. Author's experiments with the modified Willard and Winter distillation procedure showed that up to 110°C. very little fluorine distilled over; from 110°C. to 135°C. all the fluorine was recovered when sufficient distillate (about 150 ml.) had been collected; above 140°C. all the fluorine distilled over as well as some sulfuric and phosphoric acids when they were present in the sample. Results of the analyses made on 24 synthetic waters indicated that the procedure involving the colorimetric determination of fluorides after separating them from interfering substances by distillation was capable of recovering theoretical quantities of F with an error not greater than plus or minus 5% in the range of between 0.5 and 5 p.p.m. Conclusions reached by the authors are: (1) For analysis of natural waters not containing excessive amounts of interfering substances, the colorimetric method of S. gives good results; (2) In case of highly mineralized waters or waters with interfering substances the modified W. & W. distillation followed by the colorimetric estimation of F in the distillate gives reliable results; (3) In waters of unknown composition it is desirable to make the test by both methods, as a check, accepting in case of discrepancy the value obtained after distillation. With exception of cases involving unusual waters, there is a constant agreement in the values obtained by the two methods.—*J. M. Sanchis.*

The Colorimetric Determination of Fluorine in Water. George Gad and Käte Naumann. Gas.-u. Wasser. **81:** 183 (Mar. 12, '38). The importance

of the determination of fluorine is mentioned. Interferences by iron, aluminum phosphates, borates, silicates and sulfates are discussed. Complete instructions given for five methods for the determination of fluorine in water (all different from Standard Methods). Sanchis' method using zircon-alizarinesulfonate is described, and also a method using fundamentally the same chemicals but allowing development of the color in the sample to be tested. Similarly two methods are given using a zircon-haematoxylin reagent which is new for the determination of fluorine but which is more sensitive and allows the determination of .1 p.p.m. F in a 50 ml. sample as compared to a 100 ml. sample needed by using zircon-alizarinesulfonate. The standards with this new reagent are fairly stable. The above four methods use a mixture of sulfuric and hydrochloric acids to compensate for the interference of the sulfate ion. Finally a method is given using the steam distillation of fluorine as fluo-silicic acid which avoids all disturbance by interfering substances.—*Max Suter.*

Determination of Fluorine in Potable Water. V. P. SHVEDOV. Zh. prikl. Khim., Leningr. **9**: 2316 ('37); Chim. et Industr. **39**: 71 ('38). In determining fluorine in water, the most accurate results are obtained by a colorimetric method which depends on the fact that fluorine turns to yellow the red color of a mixture of sodium alizarine sulfonate and zirconium nitrate. 50 cc. of the water to be tested are treated with 10–20 cc. of 3 *N* hydrochloric acid and 2 cc. of a solution of 0.87 grams of crystallized zirconium nitrate and 0.17 grams of sodium alizarine sulfonate in 200 cc. of water diluted in the proportion 15:100. When the water to be tested is turbid or colored, the fluorine may first be distilled as fluosilicic acid.—*W. P. R.*

Arsenic in Drinking Water,—its Detection and Removal. H. STOOF AND L. W. HAASE. Vom Wasser **12**: 111 ('37). Arsenic has generally been detected only in traces in drinking or ground water, although it is common in many rocks. 0.15 mg. arsenic per liter usually considered maximum amount allowable in drinking water but a drinking water in S. W. Africa was found to contain as much as 0.5 mg. arsenic per liter. Arsenic is precipitated with ferric hydroxide forming insoluble ferric arsenate; it may therefore be removed by addition of iron and alkali and filtration through sand or Magno material. Details given of experimental work using Magno filter for its removal. Colorimetric method of detection and estimation is reduction to arsine and coloration of mercuric bromide test papers.—*W. G. Carey.*

Determination of Arsenic, Antimony, and Tin in Lead-, Tin-, and Copper-Base Alloys. JOHN A. SCHERRER. J. Research Nat. Bur. Standards **21**: 1 (Jul. '38). Detn. of Sb and Sn in Pb-base and Sn-base alloys is usually made by titration with oxidizing reagent in soln. of the alloy in H_2SO_4 and HCl. In case of brasses and bronzes, Sn, Sb and As are usually first sepd. by digesting with HNO_3, Sb and Sn then being detd. by titration and As detd. by titration after distn. from soln. of separate sample. Methods of this type are subject to limitations and results are usually high for Sb and low for Sn. For rapid control purposes, such detns. are satisfactory, except when relatively

small amts. of Sb (up to about 20 mg.) are involved, in which case Sb may be 2-3-fold high. With Pb-base alloys, most of Pb must first be eliminated as $PbSO_4$ or $PbCl_2$. In customary procedure for removal as $PbSO_4$, ppt. retains more or less Sb, Sn and As, but if $PbSO_4$ is pptd. in presence of HF, only traces of these elements are retained. Method described in which As, Sb and Sn are sepd. from most of Pb in babbits, solders, etc., by digestion in HF, HNO_3 and H_2SO_4 and from most of Cu, Zn, Pb, etc., in bronzes and brasses by digestion in HNO_3, or pptn. with NH_4OH. The 3 elements are then converted to sulfates, As and Sb reduced to trivalent state, and 3 then sepd. by fractional distn. and detd. by titration. Procedure given in detail and results are shown to be accurate.—*R. E. Thompson.*

Detection of Copper. N. A. Tananaev and S. I. Paleĭ. J. Applied Chem. (U.S.S.R.) 11: 131 (in French 134) ('38). To Cu^{++} soln. at pH 0.5, add some Pb and boil 3-5 min. to ppt. Cu upon Pb. Decant, wash Pb-Cu with water and dissolve coating by heating with few drops of concd. HNO_3. Dil. with water, add 0.5 ml. of satd. NaOAc and few drops $K_4Fe(CN)_6$. Method will detect 0.01 mg. Cu in 1 ml. Another method, sensitive to 0.001 mg. Cu in 1 ml., is based on liberation of I_2 upon addn. of KI at suitable pH.—*C. A.*

Improved Method for Determination of Aluminum in Certain Nonferrous Materials by Use of Ammonium Aurintricarboxylate. John A. Scherrer and William D. Mogerman. J. Research Nat. Bur. Standards 21: 105 (Jul. '38). Outstanding advantage of ammonium aurintricarboxylate ("aurin") over other org. reagents for small amts. of Al is almost complete absence of color when added in excess under conditions of test. "Aurin" reagent avail. on market is not satisfactory but this difficulty has been overcome (see following abstract). Reagent should give definite pink with 0.02 mg. Al and slight straw-colored blank with no Al in 50 cc. of soln. Even with good reagent, standards prepd. by usual procedures vary considerably and fade rapidly, duplicates disagree, blanks are not uniform, and results are generally inconsistent. Procedure has been developed for detg. 0.02-0.08 mg. Al which corrects these defects. Sample is dissolved in appropriate acid and converted to sulfate by gentle fuming with H_2SO_4 (HNO_3 must be completely removed) and soln. is electrolyzed in Hg cathode cell to remove interfering elements. Vol. of soln. should then be 40-75 cc. Add 5 cc. HCl, 5 cc. glacial AcOH, and 5 cc. of 0.2% aq. soln. of tested sample of "aurin." Mix well while cautiously adding NH_4OH (if presence of rare earths or alk. earths is suspected, NH_4OH satd. with $(NH_4)_2CO_3$ should be used throughout) until cloudy appearance of dye disappears and soln. becomes clear, although still acid to litmus and still deeply colored. Place piece of litmus against inner surface of beaker, and, while stirring constantly, add NH_4OH at rate of about 1 drop every 2 secs. until about 2 cc. has been added; then add 1 drop every 3 or 4 secs. until litmus paper turns blue. Now add 5 cc. glacial AcOH, let stand 10 min., and neutralize as before. Finally, add 5 cc. NH_4OH. When soln. has cooled to room temp., compare color with that of solns. of known Al content similarly prepd. If comparison is made in 150-cc. beakers against white background,

difference of 0.01 mg. Al can readily be distinguished. Rate of adding NH_4OH is important. Even with similar rates of addn., duplicates are not always in agreement. However, reacidification, allowing soln. to stand 10–15 min., and neutralization again with NH_4OH corrects this difficulty and color does not fade. Reliability of procedure was confirmed by numerous tests. Interference of various elements, most of which would cause no concern in water anal., are discussed. Fe gives red color similar to Al even when extremely small amts. are present, and must be completely removed. Ca in amts. up to 10 mg. had no effect, but same amt. of Mg gave pink color somewhat similar to that with Al. Al can be sepd. from Mg by twice pptg. with NH_4OH after adding suitable substance such as Zr to "gather" Al. Test is then made on soln. of ppt. Zr. is without effect in amts. up to 10 mg., provided $(NH_4)_2CO_3$ is used for neutralization, NH_4OH giving copious red ppt.—*R. E. Thompson.*

Preparation of Ammonium Aurintricarboxylate. JOHN A. SCHERRER AND W. HAROLD SMITH. J. Research Nat. Bur. Standards **21**: 113 (Jul. '38). Reagent suitable for use in detg. Al (cf. previous abstract) can be prepd. as follows: Add 4 grams $NaNO_2$, in small portions and while vigorously stirring, to 44 cc. H_2SO_4 (sp. gr. 1.84) contained in 250-cc. beaker. Nitrite should be added slowly to prevent excessive evolution of oxides of N. When dissolved, cool to 10°C. Over period of 5–10 min., next add 12 grams salicylic acid, while stirring. Cool to 3°C. by immersing in crushed ice, and add dropwise 3.5 cc. approx. 37% soln. of HCOH, again vigorously stirring. Since temp. at this stage must not exceed 5°C., small thermometer makes convenient stirrer. Allow to remain in ice bath for about 1 hr., stirring every 5 min., then let reaction proceed at reduced temp. (temp. rising as ice melts) for about 20 hrs. with beaker covered. Then slowly pour into 2 liters of cold distd. water, while constantly stirring. Allow to stand for 1 hr. and filter through 15-cm. paper of close texture in Büchner funnel. Wash ppt. 3 times with distd. water and then return it to beaker in which pptn. was made. Add 1 liter of water and 50 cc. HCl (sp. gr. 1.18) and boil 2–3 min. Let ppt. settle 10 min. and wash 3 times by decantation with water. Crush black mass with stirring rod (flattened at end) and repeat boiling treatment with water and acid and subsequent washing with water twice more. Finally, dissolve residue in excess of NH_4OH, evap. to dryness on steam bath, grind cooled residue to fine powder and transfer to bottle.—*R. E. Thompson.*

Application of Fluorescence in Chemical Analysis. A. OKÁČ. Collection Czechoslov. Chem. Commun. **10**: 177 ('38). Addn. of morin to Al^{+++} soln. causes luminescence under ultraviolet light but addn. of alkali fluoride causes formation of AlF_6^{---} and fluorescence disappears. Al^{+++} or F^- can be titrated on basis of this behavior in chamber illuminated by ultraviolet light obtained by filtering light from Hg lamp. Titration succeeds best when Al^{+++} soln. is titrated with alkali fluoride soln., endpoint being more difficult to detect when approached from opposite direction. Excellent results can be obtained with very small quantities of either Al or F but it is important that definite conditions be fulfilled as results vary with slight changes in procedure.—*C. A.*

The Colorimetric Determination of Aluminum in the Presence of Fluorides. George Gad and Kate Naumann. Gas-u. Wasser. **81:** 164 (Mar. 5, '38). If more than 0.5 p.p.m. of fluorides are present they form complex salts with the aluminum which destroy the color formed in the determination of Al with alizarinsulfonate or with haematoxylin in acetic acid solution. Reagents necessary: (1) 0.1% solution of haematoxylin in 1% acetic acid prepared cold, (2) 20% solution of ammonium carbonate, (3) freshly prepared solution of 10% potassium cyanide, (4) aluminum solution for comparing results, prepared by dissolving 0.0500 gram aluminum in 2 ml. of 25% HCl and diluting to 1 liter with distilled water. Procedure: Add to a 50 ml. sample 3 drops of (3). Shake and let stand for five minutes. Then add 0.3 ml. of (1) and 1.0 ml. of (2) and shake again. Similarly treat a series of solutions containing 0.05 to 0.2 p.p.m. Al. After five min. compare the color which goes from red to deep violet.—*Max Suter.*

STERILIZATION

The Resistance of Endamoeba Histolytica Cysts to Chlorine in Aqueous Solutions. Wm. S. Stone. Amer. J. Trop. Medicine **17: 4:** 539 (July '37). Due to the more or less unanimous opinion that cysts of *Endamoeba histolytica* are much more resistant to the action of chlorine in aqueous solutions than the ordinary vegetative bacteria, the author felt that chlorine might be used to free cultures of *E. histolytica* of the accompanying bacterial flora, if none of the spore bearing organisms were present. Utilizing material of this sort various concentrations of chlorine in sterile tap water were used in an attempt to obtain viable cysts free from bacteria. It was found that when a sufficient concentration of chlorine was used to kill the bacteria (*Escherichia coli* and *Streptococcus fecalis*) present, the cysts also were killed. In reviewing previous research literature it was noted that most investigators had only determined the initial available chlorine and not the residual chlorine at the end of the contact period and that no attempt had been made to determine if the concentrations used had killed off the accompanying bacteria. Complete description of the six experiments conducted is given including material and methods used. The results are presented in tabular form with discussion. Author concludes that the cysts of *Endamoeba histolytica* (obtained from cultures) are no more resistant to the lethal action of chlorine than was *Escherichia coli,* with the qualification, however, that the data presented are purely experimental and that their application to water purification in the field will require further study.—*P. H. E. A.*

Solution for Colorimetric Standards. Permanent Series for the o-Tolidine Method for Chlorine. G. Dragt with M. G. Mellon. Ind. Eng. Chem.—Anal. Ed. **10:** 256 (May '38). Using recording photoelectric spectrophotometer, study was made of transmittancies of chlorine-o-tolidine (OT) solutions and their comparison with those of various permanent standards. Chlorine-OT color changes from yellow to blue through pH range 2.0 to 3.5, and enough acid reagent must therefore be added to produce final pH below 2.0. Even tap waters below pH 8.0 may require, per 100 cc. of water tested, 2 cc. of Standard Methods OT reagent contg. 10% of HCl by vol. Chlorine-OT solns.

show min. in transmittancy curve at 436 mμ and no absorption of light through region 560 to 700 mμ. None of the permanent standards duplicated this min. but this is unimportant since it is in far blue where sensitivity of eye is very low. All permanent standards studied except Scott's (Water Works & Sewerage, **82**: 399 ('35)) show some absorption at 600 to 700 mμ due to their $CuSO_4$ content. Also, only Scott's standards can be used in tubes of any length, all others tested being valid only for definite tube lengths. Scott standards were found to agree with chlorine-OT transmittancy curves in range 0.1 to 2 p.p.m. Discrepancies in Scott standards below 0.1 p.p.m. may be corrected as follows:

CHLORINE, P.P.M.	STOCK SOLUTION, CC.	
	Present	Modified
0.10	4.4	4.4
0.07	2.8	3.1
0.05	1.9	2.2
0.03	1.1	1.3
0.02	0.7	0.8
0.01	0.3	0.4

—*Selma Gottlieb.*

Automatic Recording and Regulating Devices in Water Treatment. R. Kroke. Vom Wasser **12**: 159 ('37). Two types of instruments are described for the continuous automatic recording of the amt. of residual Cl in the water. The first depends upon use of a photoelec. cell to record intensity of color developed in such color reactions as the o-tolidine reaction, provision being made for the continuous addn. and mixing of the reagent with the flowing water. The intensity of the color developed is a function of the temp. and correction must be made accordingly in interpreting the data. The 2nd device depends upon fact that the potential of a Au electrode in Cl_2-contg. soln. is a function of the Cl_2 concn. (and again also of temp.). Effect upon the potential produced by other substances in soln. whose concn. may vary is compensated for by using a cell with 2 electrodes sepd. by a porous wall. Chlorinated water flows through one compartment while the same water unchlorinated flows through the other. Suitable equipment records the p.d. developed. Automatic equipment is described for regulating the Cl dosage so as to secure the desired residual Cl. Current from a galvanometer connected to a cell such as just described makes or breaks contact with a motor which opens or closes the Cl feed valve. Use of the app. previously described by Splittgerber and Petersen for recording the O_2 content of boiler water is discussed and factors interfering with its satisfactory operation are considered. Among latter is the presence of slight amts. of Cu in soln. which deposits on the electrodes and acts as a "contact poison." Twelve references.—*C. A.*

The Stability of Chlorine-Water Vapor Mixtures in Light. James E. Cline and George S. Forbes. J. Am. Chem. Soc. **60**: 1699 (Jul. '38). Using

Mazda bulb, mercury arc and "Fluorlight" as sources of illumination for 365, 313 and 254 mμ wave lengths respectively, experiments indicated very probable absence of any photochemical reaction between gaseous chlorine and water vapor.—*Selma Gottlieb.*

SOFTENING AND IRON REMOVAL

Water-Softening Plant Design. W. H. Knox. Proc. A.S.C.E. **64**: 875 (May '38). The article refers particularly to practice in Ohio. If an existing well water supply has a hardness of more than 700 to 800 p.p.m. another source of supply should be sought if a water-softening plant is to be installed. Cost of chemicals is, roughly, 1¢ per 1,000 gal. for every 100 p.p.m. the hardness is reduced. Aeration is an assistance in removing tastes, odors, carbon dioxide, and sulfur. Desirable to be able to by-pass aerators. Dry chemical feed machines have almost superseded solution-feed devices except in small plants. At extremely large plants it is desirable to obtain a flash mix which is done by various patented devices. The need for flash mixing at small plants is questionable. Mechanical mixing devices are preferable to baffled chambers. Provision for frequent removal of sludge from sedimentation basins necessary because of the large quantities of sludge produced. Either a rectangular basin with longitudinal flow or a circular basin with radial flow gives satisfactory results. At small plants it may still be desirable to install settling basins without sludge-removal equipment. The disposal of lime sludge into a stream does not cause "pollution," but it does cause unsightly sludge banks. Other methods of sludge disposal practiced include lagooning, drying, incinerating for re-use, and sale as agricultural lime. Carbon dioxide is added to the water through grids of perforated pipes at a rate of about 300 lb. per mil. gal. of water treated. Duplicate units for recarbonation not needed. The design of filters for a lime-soda plant is practically the same as the filters for a purification plant. Pressure filters should not be installed unless unavoidable. The adaptation of zeolite softening to municipal plants is comparatively recent. The first municipal plant in Ohio was installed in '27. Not possible to rate the daily softening capacity of a zeolite plant by the volume of zeolite in the units, as the frequency of regeneration is another factor If iron exceeds 0.5 p.p.m. it should be removed before softening by zeolite. Questions to be decided after zeolite softening has been selected include: gravity vs. pressure units, kind of zeolite, and upward vs. downward flow. Since the zeolite-softened water has zero hardness provision must be made for mixing raw water with it to adjust to a desirable degree of hardness. Salt should be purchased in bulk for reasons of economy and provisions for proper storage are important in the design. The field of water softening is practically unlimited and offers water works engineers opportunities to serve the public.—*H. E. Babbitt.*

Design of Small Softening and Iron Removal Plants. J. J. Woltmann. Bul. Assoc. State Eng. Soc. **13**: 2: 89 (Apr. '38). Fairbury, Nokomis, and Mattoon are small municipalities in Illinois, each with relatively hard water supply. Plants at Fairbury and Nokomis designed for 300 g.p.m. and

250 g.p.m., to handle waters with total hardness of 356 p.p.m. and 560 p.p.m., respectively. They are, in most respects, of conventional type including coke tray aerator, chemical mixing tanks, sedimentation basin, recarbonation basin, filters, clear well, sludge removal equipment, and lagoons. At Mattoon water has hardness of 162 p.p.m. Plant has capacity of 2.25 m.g.d. It consists of two mixing tanks, with periods of 10 min. and 50 min. respectively, equipped with paddle mixers. Existing sedimentation basin, with period of 4 hr. was supplemented with a new basin with period of 1 hr., equipped with sludge-removing mechanism. Portion of the old settling basin was rebuilt to serve as a recarbonation basin. There are four filter units and a 30,000 gal. wash water tank.—*H. E. Babbitt.*

Results of a Hydrogen-Permutite Water-Softening Plant. S. SCHUBERT. Arch. Warmewirt. **19**: 129 ('38). An org. base-exchange material was employed. Regeneration was with HCl soln. followed by NaCl soln. The plant is very reliable; no loss in efficiency or corrosion was observed after 1 year.—*C. A.*

Why Softened Water? KUELLING AND JEFFREY. Bul. Assoc. State Eng. Soc. **13**: 3: 116 (Jul. '38). Development of water softening, on a large scale, is credited to Thomas Clark of Aberdeen. Under impetus of Clark's work and later identification of zeolites by Cronsted and their practical application for softening uses by Gans in '06, the European countries, particularly England, led the rest of the world in the development of water softening for industrial and municipal purposes. First municipal water softening plant in the United States was constructed at Oberlin, Ohio in '05. At present there are 372 municipal water softening plants in this country, serving approx. 7,000,000 people. Increased value of softened water from consumer's standpoint can be considered under three general headings: economic, public health and safety, and personal convenience. Average water consumer is not aware of the many benefits derived from softening water in a municipal plant and a most thorough job of educating him in these facts is needed in promotion of a municipal softening project.—*H. E. Babbitt.*

Why Water Softening Attracts Industries, Promotes Health and Saves Money. ERNEST EBERHARD. Pub. Wks. **69**: 3: 20 (Mar. '38). Water supply may be major factor in promoting feminine beauty, health, plumbing and heating system efficiency, in attraction of industry, and in flavor of cooking and spotlessness of linens. In Madison, Wis. gas company finds that it costs $5.20 a yr. for water heater cleaning service where raw water is used as against $1.25 when soft water used. Fuel waste due to boiler scale may average $6.00 per yr. per family. ¼" scale on inside of 1" pipe will cut capacity to 25%. Probable that av. waste of soap per family, in hard water districts, runs around $16.50 per yr. N. Y. Health Dept. states washing clothes in hard water will reduce life 20 to 40%. Leguminous foods as peas, beans and lentils are made tough when cooked in hard water. Clear, sparkling, soft water attraction to industries using much process water. Increase in water sold after softening

may be as much as 250%. Suggestions given of methods of promoting interest in and construction of water softening plant for public supplies.—*Martin E. Flentje.*

Water Softening. A. L. BANKS. London County Council Ann. Rept. 4: 127 ('36). A brief survey of the literature dealing with the effect of hard water on health. No evidence is available to show that the incidence of disease in areas supplied with hard water is any greater than in areas supplied with soft water. The drinking water of many health resorts is hard. It has been pointed out that the calcium content of milk is much higher than that of hard water. Experiments with calves and chicks showed that those supplied with hard water developed rather better than those supplied with distilled water. In Germany it has been shown that the condition of the teeth was better in communities using hard water. The advantages of a softened water in increased cleansing power and prevention of scale formation in boilers and pipes are offset by the solvent action of soft water on metals, especially lead, and the possible deterioration in bacterial condition and palatability of the water due to exposure during softening. Filtration and chlorination of water do not greatly affect the content of iodine but a larger loss of iodine takes place during softening by lime.—*W. P. R.*

The Ferrous-Ion Concentration of Ground Water and its Variation. J. SEEBERG. Acta Univ. Latviensis, Lauksaimniecibas Fakultat. Ser. 3: 4-7: 325 ('37). Factors influencing the soln. of Fe in ground waters and reasons for observed variation in ferrous content are discussed and attempt is made to det. the processes involved and the factors influencing the spontaneous sepn. of Fe from ground waters. Lab. expts. on the degree and velocity of spontaneous sepn. of the Fe are reported on a large no. of waters. The waters were kept in closed flasks protected from air except for the air space in the flasks. Waters showing apparently no essential differences in properties still showed great variation in the degree and velocity of sepn. of the Fe. Large variations were usually encountered only when the original Fe concn. was high and the $KMnO_4$ consumption low. With exception of a few cases, when there was no free access to the air the Fe sepd. only partially and then over a period of 3-8 days, occasionally less than 3 days. This phenomena could be regarded as result of an O_2 deficiency only when the air space above the water was slight. Total sepn. of the Fe was dependent on the presence of much hardness. A higher original Fe content required greater hardness for sepn., the relation being linear. When original Fe content was low (below 0.15 p.p.m.) the degree of sepn. of the Fe varied between wide limits (20-95%). The degree of sepn. increased with higher concns. of Fe (varied between 50 and 90%). This was due to fact that oxidation was more rapid at higher concns. and stability of the $Fe_3(OH)_3$ sol decreased. In general, at very high Fe concns. the degree of sepn. varied only within narrow limits and approached 100%. The exception observed was a soft water high in org. matter. In only 20% of the waters studied did the residual Fe concn. exceed 0.1-0.2 p.p.m. Pptn. was ordinarily very complete and slow from spring, river and lake waters. The degree of

sepn. of the Fe was high in H_2S-contg. waters. In waters high in chloride pptn. was very slow, even in spite of considerable hardness and low $KMnO_4$ consumption. While a linear relationship was indicated between degree of sepn. and hardness, the ratio of temporary to permanent hardness seemed to have no effect except in cases of very slight or very high sepn., when effect of temporary hardness was predominant. Influence of original Fe concn. and the content in org. matter on the degree of sepn. of the Fe were studied. Lab. expts. indicated that the difference between the degree of sepn. of Fe when the water was kept in a closed vessel and when the surface was exposed to the air of the room was large. Expts. with peat waters showed that degree and speed of sepn. of Fe was detd. by the type of peat, the degree of sepn. being usually 40–70%, sometimes as low as 10%. A bibliography of about 250 references is given.—*C. A.*

Rapid Test for Strongly Ferruginous Well Waters. O. SCHMATOLLA. Pharm. Ztg. **82**: 81: 985 ('37); Chim. et Industr. **39**: 71 ('38). Well waters containing iron may be tested by pouring 200 cc. of the fresh well water into a mixture of 3–4 cc. of 10% ammonia and 0.3 gram of salicylic acid. A pronounced yellow color will generally form immediately if ferrous compounds or substances containing iron are present.—*W. P. R.*

CORROSION

Estimation of Corrosive Power of Water. R. STROHECKER. Vom Wasser **12**: 128 ('37). Estimation of aggressive carbon dioxide is usually made by Tillmans' method, combined carbon dioxide being found from methyl orange titration and free carbon dioxide by titration with sodium hydroxide using phenolphthalein. Possible errors in latter are pointed out. Tillmans assumed that end point in bicarbonate solution was at pH 8.3, experiments now show it to be at pH 7.8. Schilling and Budenbender find that end point depends on concentration,—in strong solution it is at 8.3, in dilute solution comparable to drinking water it is at 6.9. Formula, —pH = 11.49 − log CaO − log combined carbon dioxide, is derived to calculate pH value of water to determine its aggressive power. Reference is made to similar formula of Langelier in U. S. A. by which pH value is calculated from calcium ion concentration, methyl orange alkalinity, ratio of $\frac{H \cdot CO_3}{HCO_3}$ and solubility products of carbon dioxide and lime, and author's results agree with Langelier's. Aggressive power of water can be stated quantitatively as difference between free carbon dioxide and combined carbon dioxide, this being aggressive carbon dioxide. Magnitude of difference between actual pH of water and pH of same water in equilibrium with calcium carbonate shows approximately whether water is strongly or weakly aggressive.—*W. G. Carey.*

Copper Pipes and Galvanized Tanks in Water Systems. ANON. Wtr. and Wtr. Eng. (Br.) **40**: 299 (Jun. '38). Investigation is in progress to prove whether corrosion of galvanized hot water tanks is accelerated by use of copper pipes in circulating system. Although combination may be perfectly successful with some waters it is found that certain types of water, e.g. those with high

free carbon dioxide, dissolve small amount of copper and in consequence are liable to cause corrosion in galvanized coatings. This corrosion not due to contact of dissimilar metals and can not be avoided by insulating the two metals from each other. It is considered to be due to traces of dissolved copper in the water.—*W. G. Carey.*

A New Contribution to Corrosion by Hot Water. L. W. HAASE. Kleine Mitt. Ver. Wasser-, Boden-u. Lufthyg. **13**: 331 ('37). Discusses the causes and prevention of corrosion in hot water supply plants. Prevention of corrosion by addition of chemicals which will combine with dissolved oxygen and by the protection of iron surfaces from oxygen by adding to the water colloidal substances or chemicals such as soluble phosphates which form protective layers on the metal surface are considered. Both processes loosen and remove rust deposits and protect iron pipes which are in contact with copper structures. The use of copper parts in hot water supply systems and the cause of the corrosion of iron and galvanized iron pipes which are connected to copper are dealt with. Investigations show that such corrosion is caused not by galvanic currents between the iron and copper parts but by the action of copper which is dissolved by the water and deposited on the iron or galvanized iron surface. Local elements are set up where the copper is deposited and pitting occurs. Copper only deposited on clean metal and not on rusted surfaces. The solution of copper depends on the composition of the water and is increased by presence of chlorides. The influence of the size of the copper surface and of the temperature have not yet been definitely determined. The importance of rendering the cold water supply non-aggressive in flow-through heaters is pointed out. Use of galvanizing to prevent corrosion of iron and the corrosion of zinc coatings are considered. The corrosion of plants of copper and iron cannot be prevented simply by inserting insulating material, such as glass, porcelain or asbestos cement, between the two metals. Treatment of the water is necessary to reduce the solution of the copper and to induce the formation of a protective layer in the iron pipes; it may be preferable to remove the copper from the system or to use iron pipes with protective coatings, e.g. of artificial resin, which are resistant to hot water. The prevention of corrosion by passing the water through a Magno filter is discussed. Observations are described which indicate that the protective action of this process is mainly due not to the formation of a protective layer but to the removal from the water of suspended impurities and, where copper is used, to the reduction of the solubility of the copper. The possibilities of using filters of other materials such as sand instead of Magno filters and of water works supplying cold water which is not only non-aggressive but also capable of forming protective layers in hot water supply plants are considered.—*W. P. R.*

Deposition of Scale Below Boiling Point. Occurrence, Prevention and Removal. E. GORDON BARBER. Fuel Economist **13**: 498 ('37). Deposition of scale at temps. below the b. p. is due almost entirely to temporary hardness or in some cases to org. matter. Certain algae grow at 100° and considerably increase scale deposition in cooling systems, etc. Prevention of such growths through sterilization by chlorination and partial or complete removal of tem-

porary hardness by treatment with H_2SO_4 or caustic soda are discussed. Removal of scale by treatment with HCl is also discussed. The addn. of tannin to the acid reduces considerably the attack of the latter on cast Fe and mild steel.—*C. A.*

Underground Corrosion of Pipe. K. H. LOGAN. Chem. Met. Eng. **45**: 422 (Aug. '38). Industrial corrosion problems somewhat different from those connected with long pipe lines and net-works both as to relative importance of causes and methods of mitigation. Many conditions create differences in electrical potential between small areas on a buried metallic structure and on other areas on same or adjoined structure. Tendency exists for establishment of electrical equilibrium in which charged particles (cations) move out of the metal at point of high potential to point of lower potential. This is first step of corrosion process, seriousness of procedure depends on number of migrating particles leaving in unit time and duration of process, this depending in turn on what happens to migrating particles. Under most conditions cathodic area protected against corrosion. Differences of potential numerous and while they may indicate possibility of corrosion, other factors must also be considered. Brass corporation cock in c.i. main example, shows considerable difference of potential but usually little corrosion of iron due to large area of distribution of corrosion action. Most cases of underground corrosion result of corrosive soils or soil conditions. Protection gained by use of corrosion-resistant materials and use of protective coatings. Difficult to get continuous coating free from pinholes, thin spots, and abrasions. Cathodic protection also suitable. Measure best fitted to local conditions must be decided upon by man on job.—*Martin Flentje.*

Influence of Corrosion upon the Strength Properties of Cast Iron. E. PIWOWARSKY. Z. Ver. deut. Ing. **82**: 370 ('38). Preliminary results of investigations are given. Various types of c.i. were exposed to corrosion by tap water, sea water contg. 3.5% NaCl and artificial sea water contg. 3% NaCl and 0.1% H_2O_2, and changes in phys. properties were observed. Preliminary corrosion in tap water had least effect upon deflection and impact strength, but more noticeable effect on tensile strength and shear resistance. Concluded that type of corrosion met under ordinary service conditions of c.i. has no serious effect on phys. properties. More important, as is shown by results of tests, is effect of corrosion fatigue.—*C. A.*

Submerged Outlet Valves at Burrator Reservoir. ALLEN ATKINSON. Surveyor (Br.) **93**: 859 (Jun. 24, '38); also Wtr. and Wtr. Eng. (Br.) **40**: 415 (Aug. '38). The replacement of valves in a reservoir at depths up to 78′ involved employment of deep-water divers. The replaced valves were of the submerged-cone type and controlled flow in 25″, 30″, and 36″ outlets. Operation of the valves became unsatisfactory, and their inaccessibility made inspection, maintenance, or modification impossible except by a diver. Such inspection revealed the valves clogged with debris, parts bent, and badly corroded. No appreciable corrosion of delta bronze or Admiralty gun-metal parts after 37 yrs. immersion. Severe corrosion had taken place in mild steel

girders; and brass showed considerable dezincification. Wrought iron was completely destroyed. Lead was considerably corroded, and copper showed moderate corrosion. With cast iron there was considerable "graphitization." Rubber joint rings were in fairly good condition. Because of these undesirable conditions decided to replace the old valves. New valves were attached directly to bellmouths of outlet pipes by special clamps cast integrally as part of valve. Removal of old valves and parts by divers was hampered by milky water resulting from cutting away of submerged concrete. This difficulty only partly overcome by daily, high-pressure jet flushing before starting work. New valves now functioning satisfactorily.—*H. E. Babbitt.*

The Problem of the Incrustations in the Cold Water Conduits of the City of Buenos Aires. S. Lajmanovich. Bol. Obras Sanitarias Nacion (Buenos Aires). **2**: 295 (Mar. '38). Review of the physico-chemical, biological, and biochemical theories of pipe tuberculation. Author's conclusions are that regardless of the mechanism involved in the production of incrustations, the most effective way to eliminate them is to prevent the metal surfaces from coming in contact with the water. The formation of a protective coating by treating the water with lime (as suggested by Baylis, Hale, Schilling & Langelier) or by use of sodium silicate (advised by Speller) is recommended.—*J. M. Sanchis.*

PROTECTIVE COATINGS

Magnetic Method for Measuring the Thickness of Nonmagnetic Coatings on Iron and Steel. Abner Brenner. Jour. of Research, Nat. Bur. of Stds. **20**: 357 (Mar. '38). Non-destructive method of measuring thickness of coatings on iron and steel desired, article reports on extension of magnetic measurement methods previously developed to testing of non-magnetic coatings. Method depends on reduction in magnitude of attractive force between magnet and metal when coated with a nonmagnetic coating. Magnitude of reduction depends on coating thickness. In practice permanent magnet is brought into contact with coated steel and force required to detach measured, decrease in force required due to coating allows thickness of coating to be read from appropriate calibration curve. Spring balance instrument for measuring detaching force is described. Magnet chosen is rod 36% Co steel, 0.04" (1 mm.) diam., and 1.2" (30 mm.) long. Useful range includes coatings from 0.0001" to 0.015" thick, not sensitive enough for coatings on tin plate (about 0.0001"). Methods of testing and calibration are described. Precision and accuracy of method are affected by: (1) smoothness of surface, polished steel surfaces giving readings within about 1% error, rough surfaces may be burnished to give good results; (2) curvature of surface, no appreciable error being found on cylindrical rods more than 0.125" diam.; (3) thickness of base metal has no effect on accuracy if more than 0.01" thick; (4) magnetic properties of base metal, different types of ferrous metal requiring separate calibrations; (5) magnetic properties of coatings, can be used on certain magnetic coatings also. Magnetic method described shown to be accurate enough for most commercial requirements.—*Martin E. Flentje.*

Mortar-Lined Steel Pipe Adopted for Large Mains. ANON. W. Cons. News 13: 306 (Aug. '38). Electrically welded steel pipe lined with centrifugally-placed cement mortar and protected on outside with Gunite is used for mains over 20″ diam., and as alternate with 20″ c.i., by East Bay Munic. Util. District. Result of 40 yr. experience shows effectiveness of this design to provide protection against interior and exterior pipe corrosion. In lining pipe is revolved at speed of 2500 ft. per min., lining averages not less than ½″ thick with ⅜″ min. and ¾″ max. resulting in Hazen-Williams C. of 140–145. Mortar used 1 part cement to 3 parts well graded sand, mixed 2 min. dry and 3 min. after water added. Gunite coating of ¾″ thickness placed over 13-gage wire mesh. Smaller sizes than 20″ impractical because of necessity for placing mortar by hand to complete inside joints.—*Martin Flentje.*

New Equipment for Coating Pipes Built by the Institution. DANTE I. CASALE. Bol. Obras Sanitarias Nacion (Buenos Aires) 1: 657 (Jun. '38). Experience during past 10 yrs. has shown that interior coatings of cement mortar are superior to those of other types for protection of cast iron pipes in Argentina. To effect economies through saving of royalties formerly paid for use of patented processes, the shops of the National Sanitary Works Dept. have developed following procedure for lining of pipes: Bell end of pipe to be coated is held by clamps and special centering devices to the wheel of a lathe while other end of the pipe is supported by an adjustable device mounted on a steel beam which forms the lathe bench. In operation, pipe is rotated by the lathe while a movable cement gum, equipped with a nozzle a little longer than the pipe being coated, is used to force the mortar uniformly against the pipe wall. A few trial runs with the experimental machine indicate that the new process is capable of doing the same amount of work in one-fifth of the time formerly needed by the old procedure.—*J. M. Sanchis.*

Painting in the Municipality. F. PUPIL. Technique Sanitaire (Fr.) 32: 40 (Feb. '37). Historical review of art of painting. Hygienic role of paint in hospitals, railway stations, theatres, factories, etc., and its relation to methods of cleaning in practice. Without paint, use of iron and steel would be greatly limited. Comparative test is illustrated. Four zinc whites of great purity but of different makes were made up with six different drying oils (four linseed, one linseed and tung oil mixed, and one "Speciales Abrasin") each, and 24 metal plates were painted, three coats each, with the different mixtures. At same time larger scale tests on a wall were also made. Metal plates were rectangular and all of same size. After painting, a diagonal scratch was made on each plate laying bare the metal. The plates were then artificially aged and photographed. In the result, one only of the zinc whites shows perfectly with all six oils, the scratch completely healed and without discoloration of any kind. One other zinc white shows partial healing of the scratch in all six oils and only moderate to slight discoloration with three of the oils. A third zinc white shows complete discoloration with one oil, severe discoloration with another and only slight with two others. The scratch is nearly closed up on the five non-discolored plates. The fourth zinc white shows complete discoloration with three oils, and slight to moderate with the other

three: one scratch is completely and two others partially healed. These great differences believed due to presence of traces of impurities so slight as hardly to be detectable. Importance is stressed of ability to heal up cuts, iron oxide paint of good quality possesses it; it adds greatly to rust-resisting power. Rate at which viscosity disappears is also important: a thin coat, for instance, dries quickly. Rate of drying must correspond to rate of application; if too rapid, the paint cannot be applied evenly; if too slow, it flows down in streaks. The paint when applied separates into a coagulum and a liquid. It is the liquid which heals up injuries, comes to the surface and determines glossiness or otherwise. Importance of rust-prevention is supported by statistics: rust consumes one-fifth of all the iron made. The Iron and Steel Institute has estimated that in 43 yrs., 1890–1933, the world production of iron was 1,766 mil. tons while world loss by corrosion was 718 mil. tons. The Oil-Gas Journal in '28 estimated that 20% of the surface area of the plates used in big tanks is corroded annually by rust. Iron with a concrete coating of 1″ to 2″ thick is secure against corrosion: hence the evolution of ferro-concrete. In order to protect iron by paint, one of three courses is followed: (1) painting before any attack by rust, (2) awaiting loosening of scale and then painting on the bare iron, or, (3) cleaning by sand blast, with paint immediately following. Red lead paint generally recommended for priming. It retains elasticity for considerable time, but red lead being unstable to air and light, a further protective coating is necessary. Iron oxide paint depends for reliability on quality of pigment, which should be such that injuries heal up; thixotropic property is as yet insufficiently studied. Oil paints, whether red lead, iron oxide, graphite, or aluminum, are not completely satisfactory, for several reasons. One is that, as the oil oxidizes, harmful acidic bodies appear. Another is that, under water, oil film harbors corrosive bacteria,—a recent observation. Sub-aqueous corrosion may result from association of various bacteria, some aerobes, some anaerobes, some sulfur bacteria, which last named are able to form sulfides at the expense of the iron, even under water. Paints recently made from pitches of various kinds and aluminum have valuable properties. They can be applied very thin, which is essential, and the aluminum quickly comes to the surface and forms a coating of interlocking plates. The dark appearance of the paint as applied quickly changes to brilliant. This coating is remarkably weather-resistant and is also excellent under water. The application of paint is finally discussed, including the controversial question of gun vs. brush.—*Frank Hannan.*

HYDRAULICS

Flow of Water Through 6-Inch Pipe Bends. David L. Yarnell. U. S. Dept. Agr., Tech. Bul. 577 (Oct. '37). Results of extensive experiments on flow of water through bends in 6″ circular pipe with various amounts of total curvature, 90° bends of hyperbolic and elliptical cross section, 90° bend of circular cross section with varying radius of curvature and 90° miter bend are presented. Research, carried out by Bur. of Agr. Engrg. in cooperation with Univ. of Iowa College of Engrg. at hydraulic lab. of latter, included studies of influence of uniform and non-uniform velocity distribution in pipe approaching bends. Tests on nonuniform velocity distribution are believed to be first experiments of their kind. Measurements were made of (1) velocity distribu-

tion in bend and in approach and discharge tangents, (2) pressure changes at various sections in bend and tangents, (3) energy changes as water passes around bend, (4) loss of head due to bend, (5) direction of filaments of flow as water moves around bend and (6) friction losses in approach and discharge tangents. Bends and approach and discharge tangents were of transparent celluloid, diam. being checked before and after each test and allowance made for any variation. Results obtained are depicted in 102 pages of graphs and diagrams. Conclusions: (1) All bends act as obstructions to flow, causing greater loss of head than equal lengths of straight pipe. (2) Velocities of filaments along inner side of bend are increased and those along outer side decreased, compared with velocities in tangents approaching bend. (3) Loss of head increases with increase in length of bend, for pipe of equal size, equal radius of curvature, and like material and condition, and is greatest for bend in which tangents are joined without intervening curved section. Compared with 90° standard bend, loss of head in 45° bend was 0.75, in 180° continuous-curvature bend 1.25, in 180° reverse-curvature bend 2.1, in 270° bend 2.7 and in miter bend 7.8. (4) Loss of head is greatly influenced by velocity distribution in approach tangent. With velocity in approach tangent high toward inner side, losses of head in all bends ranged from about 1.5 to 4 times that with uniform velocity. With approach velocity higher toward outer side, some bends showed slightly less and some slightly greater losses than with uniform velocity. With high velocity at top of approach, loss was 1.25 to 2 times that with uniform velocity and with high velocity at bottom, loss was 1.3 to 3 times greater. In each instance velocity on high side was about 3 times that on low side. (5) It is possible to compute mean velocity and therefore quantity of flow from difference between pressures on inner and outer sides on a bend at point of max. difference. Thus, after calibration, a bend may be used as flow meter. Difference in pressure, as in Venturi meter or Pitot tube, varies with second power of velocity and experiments indicate that errors likely to be involved are no greater than those experienced with other devices named. Observations made showed that single piezometer on bend or close to bend in tangent may not give correct av. pressure in conduit at the cross section. It is important, therefore, in such work as efficiency tests on pumps, that piezometer determinations be made at several points in any section. There is considerably greater loss of head in bends of reverse curvature than in bends of continuous curvature. It is advantageous, therefore, to avoid reversal of direction of curvature by bends placed near together. With 2 bends on same line curving in same direction, second will cause less loss of head than first if bends can be placed near together. Cast iron bends would doubtless cause greater loss of head than celluloid bends tested, owing to greater roughness and resulting secondary currents of greater intensity and magnitude, but tests made indicate relative effects of characteristics of bends.—*R. E. Thompson.*

Pressure Losses for Fluid Flow in 90° Pipe Bends. K. Hilding Beij. J. Research Nat. Bur. Standards **21**: 1 (Jul. '38). Work discussed, which forms part of extended study of pipe bends in progress at Nat. Hydraulic Laboratory, was undertaken to obtain information which would assist in correlation of previous results and to furnish data for engineering use. Steel tubing of

nominal 4" i.d., in 7'–8' lengths, was used. All joints were simply butted together and held in place by friction clamps around pipe connected by bolts, watertightness being secured by wrapping of rubber tape laid in gasket shellac, covered with layer of friction tape. Each piezometer connection consisted of 4 holes, 4 mm. diam., at 90° intervals in the circumference. Discharge measured in weighing tanks and time measured by stop watch, conditions being adjusted to obtain min. precision of 1 in 2000. Results given and discussed under following headings: resistance coeff. for straight pipe, bend coeffs., tangent coeffs., and deflection coeffs. Plotting of bend coeffs. as functions of Reynolds no. indicates that, in general, coeffs. are independent of Reynolds no. Av. values are also plotted as functions of relative radius, i.e., ratio of bend radius, R, to pipe diam., d. In another figure, values obtained are compared with those of other investigators: quantitative agreement is not good, even with due allowance for experimental errors, and it appears that variables other than Reynolds no. and relative radius are involved. Qualitatively there is some agreement in that curves indicate 2 regions of flow. For lowest relative radius, coeff. decreases rapidly to min. in neighborhood of $R/d = 5$, then there is gradual rise to apparent max. somewhere near $R/d = 15$. Finally, as relative radius gets very large, there is probably third region in which coeff. decreases, presumably approaching zero as relative radius approaches infinity. It may be concluded that in range from $R/d = 5$ to $R/d = 15$ or 20, bend coeff. is not function of flow, relative radius and roughness only. Some other variable or variables enter which produce what appears to be a sort of instability manifested by wide range in results obtained by different or the same worker. Probable explanation is relatively small disturbances of entrance conditions, or small geometrical irregularities. Great disadvantage of ferrous pipe for hydraulic experiments is progressive rusting, which results in continually changing roughness. In addition, pressure indications are falsified by ridges of rust which build up around piezometer holes. Regardless of relative magnitude of roughness effects, for final solution of bend problem it will be necessary to deal first with smooth pipes and then with pipe of known and unvarying roughness, i.e., pipe artificially roughened. Probably some of discrepancies between results of different observers is due to extraneous factors, such as irregular pipe joints: in tests of straight 4" galv. pipe with screwed couplings, resistance coeff. was increased 10% or more by joints at 10' intervals. Interesting fact regarding resistance in downstream tangent was disclosed by investigation: for bends with relative radius less than $R/d = 8$, excess pressure loss in tangent and apparent resistance coeff. at downstream end of bend are independent of relative radius. Resistance coeffs. were same for all 6 bends of relative radius less than 8. Plotting of deflection coeffs. as functions of relative radius shows that this coeff. is zero for relative radius of about 3 or 4: in other words pressure loss in such bends is same as in equal length of straight pipe. Since energy loss in bend must be greater than in straight pipe, it must be inferred that pressure loss does not give total energy loss. Hence, complete picture of bend losses can only be obtained by determining velocity and pressure distributions in successive cross sections of bends. Eight references.—*R. E. Thompson.* (See also preceding abstract and abstract in J.A.W.W.A. **30**: 1012 (Jun. '38).)